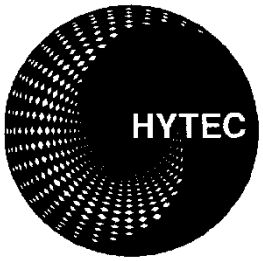
Hytec EPICS Driver User Manual



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1. General Information

The Purpose of the Document

This document intends to aid those who used, are using or will use Hytec equipment in EPICS environment. It describes in details as how to setup and configure the device drivers (mainly EPICS, and some in Linux operating system) for various Hytec carrier cards and IP modules under different operating systems such as VxWorks, RTEMS and Linux etc. It is not written for beginners. The readers are assumed to have already gained certain knowledge of:

- EPICS environment – EPICS core, database and how to build an application etc.
- Data acquisition concepts such as ADC, DAC, Digital I/O, Scaler, serial port communication and step motor controller etc.
- Various operating systems like VxWorks, RTEMS, Linux and Windows etc.

A Brief View of EPICS Application and Hytec Support

With the evolution of EPICS core from 3.13 to 3.14 and the soon coming 3.15, and the support for different architectures such as CAMAC, VME, PCI/PCIe and Micro-TCA etc. Hytec EPICS device drivers have been following all the development paths. We now support nearly all versions of EPICS and the majority of the architectures.

An overview of EPICS application architecture is illustrated below.

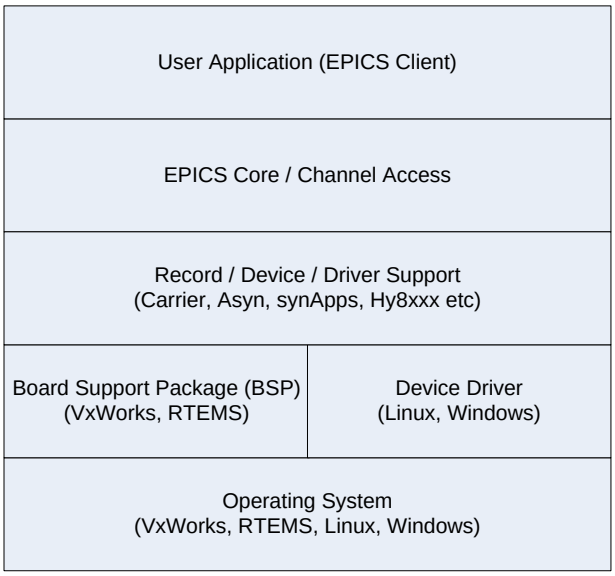

Figure 1 - EPICS Application Architecture

This document mainly focuses on EPICS core 3.14 and above.

The architectures supported by Hytec drivers are: VME/VEM64x, PCI/PCIe, Micro-TCA under operating systems such as VxWorks, RTEMS, Linux etc. Below is a table of current support matrix of different carriers (with their support modules) under different operating systems.

Table 1 – Hytec driver support matrix

Carrier	**VxWorks**	**RTEMS**	**Linux**
8002~8004 **VME**	Ipac + drvHy8002.c	Ipac + drvHy8002.c	Ipac + drvHy8002Concurrent.c Hytec VME UART device driver
6335 **PCIe**	X	X	Ipac + drvHyLinuxCarrier.c + Hytec PCI/UART device driver
7002 **MicroTCA**	X	X	Ipac + drvHyLinuxCarrier.c + Hytec PCI/UART device driver
IOC9010 **PCI**	X	Ipac + drvHyRTEMSCarrier .c + devlib2	Ipac + drvHyLinuxCarrier.c + Hytec PCI/UART device driver

X – not supported

Content of this document

The content of this document covers three parts:

- Linux device drivers
- EPICS carrier card driver (ipac)
- EPICS IP module drivers.

The Linux device drivers are only needed when building EPICS IOC on Linux PC box (PCI/PCIe bus) with Hytec carrier cards such as IOC9010, PCIe 6335 and uTCA7002/7003. These drivers have to be loaded before running EPICS application.

When using Concurrent VME processor board with Linux, Concurrent device driver has to be loaded first as well. This is supplied by the BSP (Board Support Package).

There are a number of carrier cards that are suitable for different architectures.

- VME carriers: 8001, 8002, 8003, 4004. Maximum 4 IP cards
- IOC9010 1U blade. Maximum 6 IP cards
- PCIe carrier: 6335. Maximum 2 IP cards
- uTCA: 7002. Maximum 1 IP card and 7003. Maximum 2 IP cards

IP cards include:

- ADC: 8401, 8411, 8413, 8403, 8414, 8417, 8424, 8418
- DAC: 8402, 8415
- Digital I/O: 8505, 8506
- Serial communication: 8515, 8516
- Step motor: 8601
- Scaler: 8512, 8522

2. Linux Device Driver Installation

This section is only needed when porting EPICS application on a Linux box with carrier card of either IOC9010, 6335 or uTCA7002/7003 on a normal PCi/PCIe bus PC.

For those who use Hytec carrier cards such as IOC9010 blade or PCIe 6335 or uTCA 7002/7003 on Linux system with PCI/PCIe bus, there isn't a board support package but Hytec provides a set of low level kernel device drivers to suit the EPICS support needs. These include two packages at present: PCI device driver and UART device driver.

Download the driver

The Linux PCI and UART device drivers can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx . The file would be something like this:

Hytec-Linux-Device_drivers-dd-mm-yyyy.tar.gz

PCI device driver

PCI device driver is a generic driver that functions as the BSP part which glues the EPICS carrier driver to the hardware. Almost all Hytec IP cards need it to gain access to the hardware I/O registers and memory space and handle interrupts.

The driver provides user space memory mapping to either I/O registers or memory space. This allows the fastest access to the hardware (eliminates the latency of ioctl calls). It also matches the same access mechanism as in the VxWorks or RTEMS that makes the upper layer driver (IP drivers) code operating system independent (OSI compliant).

The interrupt is a fast interrupt as well. This together with the drvHyLinuxCarrier.c driver in the IPAC module forms the interrupt mechanism of dispatching the interrupt services to the correct carrier and right IP driver code.

The PCI device driver supports multiple PCI/PCIe carrier devices such as PCIe6335 uTCA7002/7003 as well as single carrier system like IOC9010. In the case of multiple device system, each carrier is recognised by the identity (ID) settings on the carrier cards.

To install the driver,

Set up jumpers

For multiple carrier system, the carrier card ID is defined by a row of jumpers. It has 5 rows so it can define the carrier ID form 0 ~31. Please refer to hardware manual to locate the jumpers.

Note,

A. In multiple carrier system, each carrier ID has to be unique.
B. Even there is only one card in the system, you can either set the jumpers or leave all of them open which gives ID 0.

This ID will become part of the device name created by the IOC9010_create script discussed below. And it will also be passed as an argument to the carrier configuration routine when loading the carrier driver (ipac module) discussed in the next chapter.

For single carrier like IOC9010, there is no jumper to set.

Copy the tar file to the PC

Hytec-Linux-Device_drivers-dd-mm-yyyy.tar.gz

(dd-mm-yyy is the date of release)

to any directory say, /root for example and unzip it from there. It will install the code to the following directories:

PCI driver: /root/IOCBlade9010/pci

UART driver: /root/IOCBlade9010/uart

Re-build the device driver

To build the PCI device driver, go to /root/IOCBlade9010/pci directory and do a “make”.

Install the driver

To install (load) the device driver and create the device(s), execute the two scripts below in the /root/IOCBlade9010/pci directory.

IOC9010_load

IOC9010_create

The first one is to load the driver and the second one is to create the device(s). Alternatively, one can include these scripts into the .bash_profile (a hidden file) under /root for “root” user or under /home/xxx for “xxx” user so that the driver can be loaded automatically during system log in.

The “IOC9010_load” script looks like this:

```
#!/bin/sh
# $Id: IOC9010_load,v 1.4 2011/05/20 17:12:49 Jim Chen Exp $

module="9010LinuxDriver"
device="IOC9010"
mode="664"

# invoke insmod with all arguments we got
# and use a pathname, as insmod doesn't look in . by default
/sbin/insmod /root/IOCBlade9010/pci/$module.ko $* || exit 1

echo Please run ./IOC9010_create to create devices. Try ./IOC9010_create –help
```

The “IOC9010_create” script is different as per the single carrier or multiple carriers. It looks like this

```
#!/bin/sh
# $Id: IOC9010_create,v 1.0 2011/05/20 016:57:49 Jim Chen Exp $

module="9010LinuxDriver"
device="IOC9010"
mode="664"

# Remove stale nodes and replace them, then give gid and perms
# Usually the script is shorter, it's scull that has several devices in it.
rm -f /dev/${device}*

# retrieve major number
major=$(awk "\$2==\"$device\" {print \$1}" /proc/devices)

echo
if [ $# -eq 0 ] ; then
        mknod /dev/${device} c $major 0
        chmod $mode  /dev/${device}
        echo Device ${device} major=$major mimor=0 has been created.
        echo
        exit
else
        until [ -z $1 ] ; do
                mknod /dev/${device}$1 c $major $1
                if [[ $? -ne 0 ]] ; then
                        exit
```

```
                fi
                echo Device ${device}$1 major=$major mimor=$1 has been created.
                chmod $mode  /dev/${device}$1
                shift
        done
fi
echo
```

In the case of a single carrier system (IOC9010), there is only one PCI device. To create the device, just run the device creation script without parameter.

```
IOC9010_create
```

For multiple carrier system (PCIe6335 and uTCA7002/7003), the carrier IDs set by the jumpers need to be passed to the script to create different devices distinguished by the IDs as below

```
IOC9010_create 3 5
```

which will create two devices IOC90103 and IOC90105.

Check installation

To check the driver is loaded properly, run the shell command:

```
dmesg
```

It should list all the resources (memory mappings and interrupt assignment etc) acquired to the carrier card(s) by the loading process.

To check the devices created please run shell command:

```
ls /dev
```

You should see one or more IOC9010 device(s) listed there with names IOC9010x – x is the device ID number.

Uninstall

To remove the driver and devices, run command

```
IOC9010_unload
```

UART device driver

This UART device driver is specific designed for Hytec 8515/8516 serial IP modules. Upon loading the driver it automatically detects all carrier cards and all the 8515/8516 modules installed on these carriers. It then creates Linux standard UART ports for each individual serial channel of the IP cards so that the user can use them just like the normal on board serial ports such as ttyS0 ~ ttyS3 etc.

The number of tty devices the driver creates depends on the 8516/8516 IP modules. In the case of IOC9010, the maximum IP cards it can handle is 6 so the maximum tty devices the driver can create is 48 (each 8515 or 8516 has 8 channels) named from ttyHy0 ~ ttyHy47, where the first 8 ports (ttyHy0 ~ ttyHy7) are related to IP module in slot A and second 8 ports (ttyHy8 ~ ttyHy15) are related to IP in slot B and so forth or the next valid 8515/8516 IP module.

Install driver

After un-tar the zip file downloaded from the website, do a make to re-build the module in /root/IOCBlade9010/uart directory. Then go to /root/IOCBlade9010/uart to load the driver by executing

```
./uart_load
```

script.

Verify

To check the driver has been loaded properly, run command:

```
dmesg
```

and check all the resources have been allocated correctly.

Testing

To test the uart ports, minicom is a good utility for testing providing the ports are connected by either a cross cable (null modem) for 8515 RS232 or two-wire half-duplex cable for 8516 RS485 communication.

Remove

To uninstall the driver, run command:

```
./uart_unload
```

Note, although the UART driver also uses PCI device resources the same way as by the PCI device driver, the two can co-exist on the same system. They are carefully designed so that there is no resource conflict when they are working at the same time.

Concurrent VME processor device driver

This is normally provided by Concurrent BSP. The driver files are located in linuxvmeen directory after unzipping the package.

To install it, just do a make in this directory and run ./ins to install. Alternatively put the script file ins with its path in to .bash_profile file in either /root directory or /(user) directory. This will load the driver when an user is logged in.

3. Hytec Carrier Card EPICS Driver

General information and software download

As mentioned before, IP cards are installed on a carrier card. The carrier card has its own driver which provides services to the IP drivers by talking to the BSP or device drivers and to gain access to the hardware. In EPICS, the module which does this is the IPAC module plus one of the hytec carrier drivers and devLib2 in the case of using RTEMS on IOC9010 blade.

A recap, Hytec at present provides the following carriers:

- Hytec 8002/8003/8004 series for VME architecture. These carriers can handle up to 4 IP cards.
- Hytec 8001 is a two-site carrier card. It is similar to 8002 series apart from it has 64 digital channels on board.
- Hytec 6335 PCIe carrier. Each carrier can handle 2 IPs.
- Hytec single size 7002/7003 Micro-TCA carrier. Each carrier can have 1 IP.
- Hytec IOC9010. This is 1U standalone blade with PC104 processor board and PCI/PCIe architecture. Each IOC9010 can have up to 6 IP cards.

To install the drivers, first download the IPAC module from the official EPICS website

http://www.aps.anl.gov/epics/download/modules/ipac-2.11.tar.gz

or the later version.

Second, download Hytec carrier drivers from http://www.hytec-electronics.co.uk/Download.aspx .

For VME system that uses 8002/8003/8004 carrier for either VxWorks or RTEMS, please use

drvHy8002.c

For VME system that uses 8001 carrier for either VxWorks or RTEMS, please use

drvHy8001.c

For PCI/PCIe architecture with Linux and either IOC9010, 6335 or 7002/7003 carrier, please use

drvHyLinuxCarrier.c

For VME system that uses 8002/8003/8004 carrier and Concurrent processor for Linux, please use

drvHy8002Concurrent.c

For IOC9010 with RTEMS, please use

drvHyRTEMSCarrier.c

and download the devlib2 module if needed from http://epics.sourceforge.net/devlib2/

Please also refer to Table 1 for supported configurations.

Install devLib2 PCI support module

Note, this module is only needed when running your IOC on IOC9010 blade with RTEMS operating system.

Copy and un-tar the files

Copy and extract the devLib2 tar file to a directory such as “prod” of your application.

Modify configuration files

Modify configure/CONFIG file to add this line

```
CROSS_COMPILER_TARGET_ARCHS = RTEMS-pc586
```

Modify configure/RELEASE the following settings:

EPICS_BASE to point to the EPICS base

Build the library

Go to TOP and do a make.

Install IPAC module and carrier driver

Copy and un-tar the files

Copy and extract the IPAC tar file to a directory such as "prod" of your application. Copy Hytec carrier driver tar file and extract the drivers (all drvHy8001.c, drvHy8002.c, drvHyLinuxCarrier .c and drvHyRTEMSCarrier.c, drvHy8002Concurrent.c) to ipac-2.11/drvIpac directory.

Modify configuration files

Modify configure/CONFIG file to suit the specific architecture. Some examples:

- For MVME5500 processor under VxWorks

```
CROSS_COMPILER_TARGET_ARCHS = vxWorks-ppc604_long
```

- For MVME5500 processor under RTEMS

```
CROSS_COMPILER_TARGET_ARCHS=RTEMS-mvme5500
```

- For IOC9010 under RTEMS

```
CROSS_COMPILER_TARGET_ARCHS = RTEMS-pc586
```

- For IOC9010 or 6335 or 7002/7003 under Linux, you don't have to set anything.

Modify configure/RELEASE the following settings:

- EPICS_BASE to point to the EPICS base
- Add SUPPORT and devLib2 path if building IOC on IOC9010 with RTEMS. Building any other IOC's, this step is not needed. Example:

```
SUPPORT=/home/hytec/rtems/prod/R3.14.11

EPICSPCI=$(SUPPORT)/devlib2-2.0
```

Modify make file in the ipac/drvIpac folder

Modify the Makefile in this directory to include Hytec carrier driver.

- For 8002 series carrier (VME architecture) with either VxWorks or RTEMS, add this line

```
LIBSRCS += drvHy8002.c
```

- For 8001 carrier (VME architecture) with either VxWorks or RTEMS, add this line

```
LIBSRCS += drvHy8001.c
```

- For 8002 series carrier (VME architecture) with Concurrent processor and Linux, add this line

```
LIBSRCS += drvHy8002Concurrent.c
```

- For IOC9010 blade running RTEMS (PCI/PCIe architecture), add the following lines to the file

```
LIBSRCS += drvHyRTEMSCarrier.c

LIBRARY_IOC_RTEMS = Ipac

drvIpac_DBD += epicspci.dbd

Ipac_LIBS += epicspci
```

  The last two lines above are needed to include devlib2. `LIBRARY_IOC_RTEMS = Ipac i`s defined when you want to build the library module for RTEMS only.

- For IOC9010, 7002/7003 or 6335 carriers (PCIe architecture) with Linux, add this line

```
LIBSRCS += drvHyLinuxCarrier.c
```

Modify the drvIpac.dbd file

Modify the drvIpac.dbd file to suit the carrier card and architecture need.

- For 8002 series carrier (VME architecture) with either VxWorks or RTEMS, add this line

```
registrar(Hy8002Registrar)
```

- For 8001 carrier (VME architecture) with either VxWorks or RTEMS, add this line

```
registrar(Hy8001Registrar)
```

- For 8002 series carrier (VME architecture) with Concurrent processor and Linux, add this line

```
registrar(Hy8002ConcurrentRegistrar)
```

- For IOC9010 running RTEMS (PCI/PCIe architecture), add this line

```
registrar(HyRTEMS9010Registrar)
```

- For IOC9010, 7002/7003 or 6335 carriers (PCIe architecture) with Linux, add this line

```
registrar(HyLinux9010Registrar)
```

Shell command to load the carrier driver in st.cmd

In IOC application start up script, the carrier driver needs to be loaded before any IP drivers can be loaded. This is done by the carrier driver configuration shell command. Clearly different architecture uses different driver subsequently different configuration command.

For 8002/8003/8004 VME carrier with VxWorks or RTEMS

The carrier configuration command is

```
IPAC0=ipacAddHy8002(const char * "cardParam")
```

The parameter string (cardParams) should comprise two (2) to six (6) parameters which are comma separated. The first two are mandatory and have to be separated only by one comma. The others are key/value pairs and are optional. The format is defined as

s,i,IPMEM=d,IPCLCK=d,ROAK=d,MEMOFFS=d

where **d** -- is a decimal integer number.

s -- defines the VME slot number of the carrier card. Valid number is 2 ~ 21. This number MUST be the same as the VME slot number where the carrier card is plugged in.

i -- defines the interrupt level. Valid number is 0 ~ 7.

IPMEM=d -- defines the maximum memory size of the IP module. The valid values are 1, 2, 4 or 8 that represent 1MB, 2MB, 4MB or 8MB respectively. Default is 1. For majority Hytec ADCs, DACs such as 8401, 8414, 8417, 8402 and 8415 etc, they all have 2MB on board. The user can choose to use either 1MB or 2MB. None of the Hytec IPs has more than 2MB on board memory. Other vendors might have.

IPCLCK=d -- defines the clock that its value has to be either 8 for 8MHz or 32 for 32Mhz. Default is 8.

ROAK=d -- if d =1, it defines carrier card to release the interrupt upon the acknowledgment. If d=0, the interrupt is released by user interrupt service routine. Default is 0.

MEMOFFS=d -- this parameter defines the VME end A32 memory access base address. "d" is a decimal number that represents the offset (the upper WORD) of the VME end A32 base address. It is needed when any of the two statements below is true:

A. The operating system either VxWorks or RTEMS has defined a non-zero VME_A32_MSTR_BUS macro in the system config.h file.

B. The VME crate is not geographical addressing facilitated. In such a system, user must use this to set up the VME base address for A32.

For a VME crate that is geographical addressing facilitated, and the system defines a non-zero VME_A32_MSTR_BUS macro, then it is needed. But if VME_A32_MSTR_BUS macro is defined as 0, then this is optional. Setting this the driver will turn off the carrier card geographical addressing by setting a bit in the CSR.

Note: MEMOFFS has nothing to do with A16 base address formation. A16 base address is determined either by geographical addressing or by carrier board on board jumper settings. For VME crate that is not geographical addressing facilitated, both 8002 and 8004 carriers need to use on board jumpers (J6~J10) to set up (On 8004 carrier, moving the jumpers to "manual" positions). When the VME crate is geographical addressing facilitated, for 8002 carrier, A16 base address is determined by the crate geographical addressing facility, i.e. determined automatically by the slot number where the carrier is plugged in (the actually A16 base address is determined as vmeslotnumber << 11). But for 8004 carrier, user can have a choice to either use the on board jumpers to manually set up (moving jumpers J6~J10 away from "auto" to "manual" positions) or let the geographical addressing to determine it (keep all J6 ~ J10 to "auto" position).

Calculation of MEMOFFS:

As mentioned above, MEMOFFS setting represents the upper WORD of A32 VME address. Few things need to be considered when doing the calculation: IPMEM setting and the VME_A32_MSTR_BUS and VME_A32_MSTR_SIZE macros definition in the config.h file of the BSP.

IPMEM defines the memory size per IP card. Either 8002 or 8004 has up to 4 IPs so the carrier memory size is 4 times of the IP memory. The minimum size of an IP which is also the default setting (if IPMEM is not defined) is 1MB. Hence the MEMOFFS should start from address line A22 as shown below

MEMOFFS BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	A31	A30	A29	A28	A27	A26	A25	A24	A23	A22	0	0	0	0	0	0

The MEMOFFS must be defined such that any two carriers in the same crate shouldn't have overlapped memory area. So when IPMEM changes, the starting address line for calculating MEMOFFS changes as well as illustrated below:

IPMEM	memory per IP	carrier memory size	starting address line
1	1MB	4MB	A22
2	2MB	8MB	A23
4	4MB	16MB	A24
8	8MB	32MB	A25

all address lines below this bit must be 0.

The MEMOFFS calculation also needs to take VME_A32_MSTR_BUS and VME_A32_MSTR_SIZE macros into account. These macros are defined in the BSP config.h file. VME_A32_MSTR_BUS is the start address of VME end defined by the BSP and VME_A32_MSTR_SIZE is the valid size of VME memory.

As such, the definition of MEMOFFS must be in the range between VME_A32_MSTR_BUS ~ VME_A32_MSTR_BUS + VME_A32_MSTR_SIZE. Otherwise the BSP range check will reject the A32 base address register. The user will see an error during the IOC boot time saying that the ipacAddHy8002 returned an error.

In principle, calculating MEMOFFS doesn't have to correspond it to VME slot number that the carrier is plugged in. The only thing matters is as said that any two MEMOFFS settings for any two carriers in the same crate should not overlap. Yet associating the VME slot number in the calculation just makes better logical sense and fits the natural of human being's thinking. Some examples are shown below.

Let's assume IPMEM=1 (the default setting), this gives 4MB memory space for a 8002 carrier so starting address line is A22. The remaining must be 0.

MEMOFFS BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	A31	A30	A29	A28	A27	A26	A25	A24	A23	A22	0	0	0	0	0	0

For a carrier in VME slot 2, we can define its A32 base address as 0x00400000, plus VME_A32_MSTR_BUS. For VME slot 3, it could be 0x00800000 plus VME_A32_MSTR_BUS and for VME slot 4, it could be 0x00C00000 plus VME_A32_MSTR_BUS and so forth.

Assuming VME_A32_MSTR_BUS is 0x20000000, then for VME slot 4, the calculated base address should be 0x00C00000 + 0x20000000 = 0x20C000000. Hence the MEMOFFS = 8384 (decimal, i.e. 0x20C0). For slot 5, the derived base address could be 0x01000000 + 0x20000000 = 0x21000000. Hence the MEMOFFS = 8448 (decimal, i.e. 0x2100) and so forth.

Now if IPMEM=2, this gives 8MB memory space for each 8002 carrier so the starting address line is A23. The remaining must be 0.

MEMOFFS BIT	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	A31	A30	A29	A28	A27	A26	A25	A24	A23	0	0	0	0	0	0	0

For a carrier in VME slot 2, we could define its A32 base address as 0x00800000 plus VME_A32_MSTR_BUS. For VME slot 3, the base address could be 0x01000000 plus VME_A32_MSTR_BUS and for VME slot 4, the base address could be 0x01800000 plus VME_A32_MSTR_BUS so forth.

Assuming VME_A32_MSTR_BUS is still 0x20000000, then for VME slot 4, the calculated base address should be 0x01800000 + 0x20000000 = 0x218000000. Hence the MEMOFFS = 8576 (decimal, i.e. 0x2180). For slot 5, the derived base address could be 0x02000000 + 0x20000000 = 0x22000000. Hence the MEMOFFS = 8704 (decimal, i.e. 0x2200) and so forth.

Examples:

```
IPAC0=ipacAddHy8002("3,2")
```

This configures that the carrier is in slot 3 and the interrupt level is set to 2. IP memory uses default 1MB. Clock uses default 8MHz. RORA as default and uses geographical addressing etc.

Another example:

```
IPAC0=ipacAddHy8002("5,4,IPMEM=2,IPCLCK=8,ROAK=1,MEMOFFS=512 ")
```

Here the slot is 5, interrupt level is 4. IP memory size is 1MB, clock uses 8MHz. Use ROAK. The memory offset for A32 is 512 which means its base address is 0x02000000 assuming the VME_A32_MSTR_BUS macro is set to 0x00000000.

Please note, in VxWorks and RTEMS, `ipacAddHy8002` command returns the added carrier serial number which can be passed to further IP card configuration routines. The examples above use IPAC0 to receive the returned carrier serial number. This then can be passed to subsequent IP card configuration routines. This doesn't apply for Linux system please see below.

For 8002/8003/8004 VME carrier with Concurrent processor and Linux

The carrier configuration command is

```
IPAC0=ipacAddHy8002Concurrent(const char * "cardParam")
```

The “cardParam” setting is exactly the same as `ipacAddHy8002`.

For 8001 VME carrier with VxWorks and RTEMS

The carrier configuration command is

```
IPAC0=ipacAddHy8001(const char * "cardParam")
```

The “cardParam” setting is as follow

The parameter "cardParams" is a string that should comprise 2 (the first two are mandatory) to 6 parameters that are separated by commas.

- first parameter is the VME slot number (decimal string)
- second parameter is the VME interrupt level (decimal string)
- third parameter is a name/value pair defines the type of releasing interrupt. "ROAK=1" means to release interrupt upon acknowledgement; "ROAK=0" means to release by ISR.
- fourth parameter defines IP memory mapping base address offset when neither geographical addressing nor jumpers are used. "MEMOFFS=128". Please refer to `ipacAddHy8002`.

For IOC90101, 6335, 7002/7003 under Linux

The configuration shell command is

```
ipacAddHyLinux9010(char * cardParam)
```

The parameter string (cardParams) should comprise two (2) to six (6) parameters which are comma separated. The first two are mandate and have to be separated only by one comma.

The others are key/value pairs and are optional. The format is defined as

s,i,IPCLCKA=8,IPCLCKB=8,IPCLCKC=8,IPCLCKD=32,IPCLCKE=32,IPCLCKF=32

Where:

s -- The ID number of the carrier card mentioned in PCI device driver in Chapter 2 for multiple carrier system such as 6335 or 7002/7003. This ID number is set by the on board jumpers that give the carrier ID number from 0 to 31. For a single carrier such as IOC9010 blade, it is set to 99.

i -- It is not used. Normally set it to 0.

IPCLCKA ~ IPCLCKF - Defines IP slot (A ~ F) frequencies. They are name/value pairs. The value number can only be either 8 or 32 that represent 8MHz or 32MHz respectively. These name/value pairs are optional. If a slot doesn't have the correspondent name/value pair, it defaults to 8MHz.

Examples:

For IOC9010 blade that uses Linux operating system

```
ipacAddHyLinux9010("99,0")
```

This configures a single carrier system with all IP slots set to 8MHz.

For Hytec 6335 or 7002 carrier card

```
ipacAddHyLinux9010("2,0")

ipacAddHyLinux9010("3,0")
```

This configures a multiple carrier system with one carrier ID set to 2 and the other set to 3 by their on board jumpers.

Note, under Linux we cannot define variables in the shell command to receive the returning carrier serial number then pass it to the subsequent IP configuration routines. As such we need to manually maintain the serial number. For example

```
ipacAddHyLinux9010("2,0")

ipacAddHyLinux9010("3,0")
```

will add two carriers in the system. The first one the carrier serial number will be 0 and the second one will be 1 and so forth. These numbers then can be passed to the subsequent IP configuration routines who sit on these carrier cards.

For IOC9010 with RTEMS operating system

The configuration shell command is

```
ipacAddHyRTEMS9010(char *cardParams)
```

The parameter "cardParams" is a string that should comprise at least 3 to 9 parameters with comma separated without space. The first three are the carrier card PCI addresses, i.e. bus, device, function. The remaining 6 are name/value pair optional parameters that define each IP card clock. If they are not defined, 8MHz is the default clock. But the last 6 parameters are only for IOC9010 blade at the moment. The parameters format is

b,d,f,IPCLCKA=8,IPCLCKB=8,IPCLCKC=8,IPCLCKD=32,IPCLCKE=32,IPCLCKF=32

where:

b -- bus address of the PCI device

d -- device address of the PCI device.

f -- function number of the PCI device.

IPCLCKA ~ IPCLCKF - Defines IP slot (A ~ F) frequencies. The number of each paramater can only be either 8 or 32 that represent 8MHz or 32MHz respectively. These name/value pairs are optional. If a slot doesn't have the correspondent name/value pair, it defaults to 8MHz. NOTE, these settings only apply to IOC9010 blade.

Note, to find out the PCI device addresses, in Linux do command

```
lspci
```

which will list all the PCI devices in the system. Try to find 9010, 7002 or 6335 for Hytec devices and on the left of a device entry shows the PCI address such as

01:04.0

This means, the PCI device bus=1, device=4 and function=0.

Examples:

```
IPAC1=ipacAddHyRTEMS9010("1,4,0,IPCLCKA=8,IPCLCKB=32,IPCLCF=8")
```

This configuration indicates the IOC9010 carrier PCI addresses are bus=1, device=4 and function=0; IP slot A, F use 8MHz, slot B as 32MHz. Others use default 8MHz.

4. Start up Script

The start up script is slightly different in different operating systems and architectures. The main differences lie on the beginning part of the script that loads the IOC application executable. The dbd file, carrier card configuring, IP card configuring and databases loading are almost the same.

Linux IOC

Linux IOC usually has the top part start up script something like this, providing the environment path definition file envPaths exists.

```
#!../../bin/linux-x86/example
< envPaths
cd ${TOP}
```

The envPaths file is automatically generated in the IOC boot directory and defines several environment variables that are useful later in the start up script. To be able to create this envPaths file under Linux, we need to change the ARCH variable value in the Makefile under <exampleTop>/iocBoot/iocBootexample to this (in red):

```
TOP = ../..
include  $(TOP)/configure/CONFIG
ARCH = linux-x86
TARGET = envPaths
include $(TOP)/configure/RULES.ioc
```

Below is an example of the Hy8417 IP card asyn driver testing script.

```
epicsEnvSet("ARCH","linux-x86")
epicsEnvSet("IOC","iocexample")
epicsEnvSet("TOP","/home/hytec/linux/work/R3.14.11/Hy8417ip-asyn/2-
3/example")
epicsEnvSet("SUPPORT","/home/hytec/linux/prod/R3.14.11/")
epicsEnvSet("IPAC","/home/hytec/linux/prod/R3.14.11/ipac/ipac-2.11")
epicsEnvSet("HY8417IP","/home/hytec/linux/work/R3.14.11/Hy8417ip-asyn/2-
3/example/..")
epicsEnvSet("EPICS_BASE","/home/EPICS/R3.14.11/base")
```

VxWorks IOC

VxWorks IOC usually has the following top part of the start up script.

```
#!$(INSTALL)/bin/vxWorks-ppc604_long/example
cd "/dls_sw/work/R3.14.8.2/support/Hy8417ip-asyn/2-3/example"
ld < bin/vxWorks-ppc604_long/example.munch
```

In VxWorks, after the build, it creates a .munch file which is the executable of the target.

RTEMS IOC

RTEMS IOC usually has the following top part of the start up script.

```
iocBoot=pwd()
cd("../..")
ld( "bin/RTEMS-mvme5500/example.obj")
```

RTEMS doesn't generate the munch file. It creates either the executable "example" and "example.boot" files or the ".obj" file.

The Common Part

The common part is almost the same for any operating systems. Below is an example of Hy8417 module testing script.

```
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)

#Carrier module

# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")
```

```
#int Hy8417AsynInit(char *portName,  "ADC8417"
#  int carrierNum,      0
#  int ipSlotNum,   0
#  int vectorNum,   88
#  int mode)        0 (continuous)
Hy8417AsynInit("ADC8417", 0, 0, 88, 0)

#int Hy8417AsynExtInit(char *portName,  "ADC8417"
#  int samples,     10000
#  int average,     1000
#  int offset,      0
#  int clockRate,   9 (1kHz)
#  int extClock,    0 (internal)
#  int fastADC,     1 (fast ADC, not for mca & EPID)
#  int range,       0 (+/-10V)
#  int ChannelNo,   16
#  int ChannelBit)  24
Hy8417AsynExtInit("ADC8417", 10000, 1, 0, 9, 0, 1, 0, 16, 24)


# int initFastSweep(char *portName, char *inputName,
#                   int maxSignals, int maxPoints)
# portName   = asyn port name for this port
# inputName  = name of input port
# maxSignals = maximum number of input signals.
# maxPoints  = maximum number of points in a sweep.  The amount of memory
#              allocated will be maxPoints*maxSignals*4 bytes
#$(VXWORKS_ONLY)initFastSweep("8417Sweep1","ADC8417", 16, 10000)


##########
# Hytec 8402 DAC in IP site B of the IP carrier card in slot 10.
#$(VXWORKS_ONLY)Hy8402ipConfigure (302, IPAC3, 2, 11)

#initHy8402ipAsyn("DAC", 302)
##########


## Load record instances
dbLoadRecords("db/example.db","P=CARD1,PORT=ADC8417")
#dbLoadRecords("db/examplemca.db")
#dbLoadRecords("db/exampleepid.db")

# set trace output level for asyn port "ADC8417"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                    0x01: error,
#                    0x11: errors, warnings and debug
#                    0x00: silent
asynSetTraceMask( "ADC8417", 0, 0x00 )
# all driver level messages

iocInit()
```

Please note, sometimes (and sometimes not, I don't know why, this remains a mystery to me) VxWorks shell command complains that the arguments of a single function call should not exceeded 10. So any configuration routine that has more than 10 parameters would get an error when loading the start up script. To get around this, add

```
iocsh()
```

before the configuration routine. This change the VxWorks shell configuration routine to IOC shell and the IOC shell doesn't have the limitation of 10 parameters.

5. Set up RTEMS IOC application loading for IOC9010

Note, this part is for building IOCs on IOC9010 blade with RTEMS operating system only.

After building EPICS application successfully on IOC9010 blade with RTEMS operating system, the next step is how to load the RTEMS image and run the EPICS start script.

There are many approaches of doing this such as network PXE boot, DHCP and BOOTP server or NFTS etc. Below details a method we have been using at Hytec which utilises GRUB for loading the RTEMS image and Windows DHCP and BOOTP server for loading the IOC.

Building the IOC application

Building an IOC application includes the following steps but it is not the main discussion here. Please refer to documents listed in the reference and all other chapters.

- Install EPICS core
- Install RTEMS
- Install network support module such as libbsdport for IOC9010 PC104 processor
- Install other support modules such as IPAC, asyn etc
- Install IP drivers
- Create the application
- Build application

After finishing all the steps above we will have a RTEMS image built in the application <TOP>/bin/RTEMS-pc586 folder. Taking Hytec 8506 as an example, after the build we get an image named

Hy8506example

Set up loading RTEMS image

On IOC9010, we have Scientific Linux installed hence we have the grub loader by default. We can utilise the grub loader to load our RTEMS IOC image.

- Copy the image file "Hy8506example" from Hy8506/2.0/example/bin/RTEMS-pc586 to /boot directory
- Modify /etc/grub.conf file to add two lines in red for loading rtems Hy8506example

```
# grub.conf generated by anaconda
#
# Note that you do not have to rerun grub after making changes to this file
# NOTICE:  You have a /boot partition.  This means that
#          all kernel and initrd paths are relative to /boot/, eg.
#          root (hd0,0)
#          kernel /vmlinuz-version ro root=/dev/VolGroup00/LogVol00
#          initrd /initrd-version.img
#boot=/dev/sda
default=0
timeout=5
splashimage=(hd0,0)/grub/splash.xpm.gz
hiddenmenu
title Scientific Linux (2.6.18-194.3.1.el5)
    root (hd0,0)
    kernel /vmlinuz-2.6.18-194.3.1.el5 ro root=/dev/VolGroup00/LogVol00 rhgb
quiet
    initrd /initrd-2.6.18-194.3.1.el5.img

#########add the following two lines#######
title Hy8506
    kernel /Hy8506example
########################################

title Other
    rootnoverify (hd1,0)
    chainloader +1
```

This will cause the Linux box during the boot time to display a message asking "Press any key to enter the menu...", and display all loadable operating systems. As to the above example, the menu will show:

```
Scientific Linux (2.6.18-194.3.1.el5)
Hy8506
```

Then use the arrow key to choose which operating system to load.

You might want to change the timeout=5 to longer seconds say 30 for example in order not to miss hitting the key.

Also, you can move these two lines above the "title Scientific Linux (2.6.18-194.3.1.el5) which will load your rtems app by default if you don't hit any key after the timeout elapse. This is useful when you want it to run straight away to the rtems app.

Set up DHCP and BOOTP server for loading EPICS

At Hytec the corporate network uses Windows 2003 server which has both DHCP and BOOTP server hence we just use them for our EPICS application loading.

- Find BOOTP root directory on the server, create a directory named "ioc001" (you might want to check this name defined in the rtems_netconfig.c file under EPICS/base-3-14-11/src/RTEMS/base in the "struct rtems_bsdnet_config rtems_bsdnet_config" structure definition)
- In the "ioc001" folder, create a subdirectory named "epics"
- Copy db and dbd directory from your application such as Hy8506/2.0/example in the case of the above example from the blade to the BOOTP server root/ioc001/epics directory
- Copy st.cmd from IOC9010 Hy8506/2.0/example/iocBoot/iocHy8506example to the BOOTP server root/ioc001/epics directory

Start the IOC

Once the setup has been done, we can run the IOC now.

- Reboot IOC9010 blade
- When you see the boot flash

```
Press any key to enter the menu
Boot Scientific Linux (2.6.18-194.3.1.e15) in xx seconds...
```

  Hit any key to enter the menu
- Then select Hy8506. This will boot the RTEMS build first and then try to get an IP address from the DHCP server and then start the TFTP client to get st.cmd from the BOOTP server. If everything is set up properly, the rtems should start, and EPICS and st.cmd will be loaded to run the example application.

6.Hy8505 16bit Digital IO EPICS Device Driver

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devlib2 version 2.1 or later if porting RTEMS on IOC9010 blade
- RTEMS R4.9.4 or later if RTEMS is the operating system.

Building the module library

To build the module library,

- Before building the 8505 module, the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8505.dbd which is located in the src of the module.

Testing Database(s)

There are a few testing databases in the example/Hy8505exampleApp/Db folder. They are

```
Hy8505-II-bi.db
Hy8505-OO.db
Hy8505-II-mbbi.db
```

As they are named, the first one is for input; second one is for output and one last for mbbi records.

Building an Example Application

To build an example to test the 8505 driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add IPAC moudle:

```
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8505IP=$(TOP)/..
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the "include" sub-directory, it is the include header file: vme_api_en.h
In the "lib/linux-x86" sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += drvIpac.dbd
example_LIBS += Ipac
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme appears to be a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS, which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy Hy8505-II-bi.db, Hy8505-OO.db and Hy8505-II-mbbi.db to the example Db directory and add the following lines in the Makefile of that directory:

```
DB += Hy8505-II-bi.db
DB += Hy8505-OO.db
DB += Hy8505-II-mbbi.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from the example <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.

Configuration Shell Command for Start up Script

There are two configuration shell functions to set up the 8505, Hy8505Configure and Hy8505ExtraConfig

int Hy8505Configure(int cardnum, int carrier, int ipslot, int debrate, int pwidth, int scanrate,
int dir, int intr, int clock)

where:

cardnum	EPICS card number (Defined by the user to identify the card)	
carrier	carrier serial number as discussed in chapter 3 of carrier drivers.	
ipslot	ipslot 0-3	
debrate	debounce rate	0 = none
		1 = 100Hz
		2 = 200Hz
		3 = 500Hz
		4 = 1kHz
pwidth	pulse width	0 = 1 msec
		1 = 10 msec
		2 = 100 msec
		3 = 1 sec
		4 = 2 sec
		5 = 5 sec
		6 = 10 sec
		7 = 20 sec
		8 = 50 sec
		9 = 100 sec
scanrate	input scan rate	0 = 1kHz
		1 = 10kHz
		2 = 100kHz
		3 = 1MHz
dir	0 = inputs	

	1 = low outputs / high inputs 2 = low inputs / high outputs 3 outputs Bits 2 & 3 (values 4 and 8, respectively) encode whether the input and output values should be inverted. (dir & 4) == 4 => Invert all input bits (dir & 8) == 8 => Invert all output bits
intr	interrupt vector
clock	0 = internal, 1 = external

The second configuration function

Hy8505ExtraConfig(int cardnum, int debmask, int pmask, int intmask)

Where:

cardnum	card number, same as above, 71 for example.
debmask	debounce mask. Defines which bit (if set) needs to be debounced. For inputs only.
pmask	pulse/level mask. Defines which bit is a pulse output (1) or level output (0). For outputs only.
intmask	interrupt mask bit. Defines which input bit (if set) state change would cause interrupt. For inputs only

Start up Script Example

The example script below is the start up for loading the example IOC in IOC9010 blade with Linux operating system.

```
#!../../bin/linux-x86/Hy8505example
< envPaths

cd ${TOP}

## Register all support components
dbLoadDatabase "dbd/Hy8505example.dbd"
Hy8505example_registerRecordDeviceDriver pdbbase

# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")
```

```
# Hy8505Configure(cardnum, carrier, ipslot, debrate,
#                 pwidth, scanrate, dir, intr, clock)
Hy8505Configure(71, 0, 2, 4, 3, 0, 0, 0x88, 0)

# Hy8505ExtraConfig(cardnum, debmask, pmask, intmask)
Hy8505ExtraConfig(71, 0xFFFF, 0x0, 0xFFFF)

## Load record instances
dbLoadRecords "db/Hy8505-II-bi.db", "device=DIO"
dbLoadRecords "db/Hy8505-II-mbbi.db", "device=DIO"
dbLoadRecords "db/Hy8505-OO.db", "device=DIO"

cd ${TOP}/iocBoot/${IOC}
iocInit
```

7.Hy8506 48bit Digital IO EPICS Device Driver

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devlib2 version 2.1 or later if porting RTEMS on IOC9010 blade
- RTEMS R4.9.4 or later if RTEMS is the operating system.

Building the module library

To build the module library,

- Before building the 8506 module, the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8506.dbd which is located in the src of the module.

Testing Database(s)

There are a few testing databases in the example/Hy8506exampleApp/Db folder. They are

```
Hy8506-II-bi.db
Hy8506-OO.db
Hy8506-II-mbbi.db
```

Building an Example Application

To build an example to test the 8506 driver, please use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add IPAC module:

```
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8506IP=$(TOP)/..
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the “include” sub-directory, it is the include header file: vme_api_en.h
In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += drvIpac.dbd
example_LIBS += Ipac
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme appears to be a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy Hy8506-II-bi.db, Hy8506-OO.db and Hy8506-II-mbbi.db to the example Db directory and add the following lines in the Makefile of the that directory:

```
DB += Hy8506-II-bi.db
DB += Hy8506-OO.db
DB += Hy8506-II-mbbi.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the example application from <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.

Configuration Shell Commands for Start up Script

There are two configuration shell commands to set up 8506. The first one is to set up the IP card and the second one is to set up the ports.

IP card configuration

Hy8506Configure(int cardnum, int carrier, int ipslot, int vector)

Where:

cardnum	EPICS card number (User defines)
carrier	carrier number returned by ipacAddxxxx
ipslot	ipslot 0-5
vector	interrupt vector

Port configuration

Hy8506PortConfig(int cardnum, int port, int debrate, int pwidth, int scanrate, int dir,

Int debmask, int pmask, int intmask)

Where:

cardnum	EPICS card number (User defines)
port	port number. must be 0, 1 or 2
debrate	debounce rate 0 = none 1 = 100Hz 2 = 200Hz 3 = 500Hz 4 = 1kHz
debmask	select input bits to debounce 0x0000 - 0xFFFF
scanrate	input scan rate 0 = 1kHz 1 = 10kHz 2 = 100kHz 3 = 1MHz
dir	bit0 = 0: all 16 channels as inputs

	bit0 = 1: all 16 channels as outputs	
	Bit1 encode whether the input or output values should be inverted. bit1 = 0: No inversion bit1 = 1: Invert all input/output bits	
intmask	select bits to generate interrupts	0x0000 - 0xFFFF
pwidth	pulse width 0 = 1 msec 1 = 10 msec 2 = 100 msec 3 = 1 sec 4 = 2 sec 5 = 5 sec 6 = 10 sec 7 = 20 sec 8 = 50 sec 9 = 100 sec	
pmask	select bits to pulse on output	0x0000 - 0xFFFF

Start up Script Example

Below is an strat up script for loading the RTEMS IOC with 8506 IP card.

```
#!../../bin/linux-x86/Hy8506example

dbLoadDatabase "dbd/Hy8506example.dbd"
Hy8506example_registerRecordDeviceDriver pdbbase

# For PCI/Linux IOC, use
#ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")

# Hy8505Configure(cardnum, carrier, ipslot, vector)
Hy8506Configure(71, 0, 3, 0x88)

#Hy8506PortConfig(cardnum, port, debrate, pwidth, scanrate, dir,
#                         debmask, pmask, intmask)
Hy8506PortConfig(71, 0, 4, 3, 0, 0, 0xFFFF, 0x0, 0xFFFF)
Hy8506PortConfig(71, 1, 4, 3, 0, 1, 0xFFFF, 0x0, 0xFFFF)
Hy8506PortConfig(71, 2, 4, 3, 0, 3, 0xFFFF, 0x0, 0xFFFF)

dbLoadRecords "db/Hy8506-II-bi.db", "device=DIO"
dbLoadRecords "db/Hy8506-OO.db", "device=DIO"
dbLoadRecords "db/Hy8506-II-mbbi.db", "device=DIO"
```

```
cd ${TOP}/iocBoot/${IOC}
iocInit
```

8.Hy8515/8516 Serial Port Device Driver

General Information

There are two types of driver support for Hytec 8515/8516 serial devices.

One is to support EPICS IOC's running on Linux boxes. This is provided with a Linux UART device driver which converts the 8515/8516 to normal COM ports. The EPICS application can just use them the same way of using the on board serial port ttyS0, ttyS1 etc. Please refer to chapter 2 for the device driver installation.

If the system uses Concurrent VME processor with Linux, there is also a Linux uart device driver associated to it. Loading this device driver would turn all ports on 8515 or 8516 to local tty ports. They are named ttyHy1 ~ ttyHy15 for example.

The second one is at present only for VxWorks on VME architecture that is described in this chapter. This driver was done by Paul Hamadyk [paul.hamadyk@diamond.ac.uk], Diamond Light Source.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

- ipac module version ipac-2.11 plus 8002 carrier card drivers. Please consult Diamond Light Source to get a copy.
- EPICS core R3.14.8.2 or later.

Build the module library

To build the module library,

- Before building the 8515/8516 module, the ipac driver has to be built successfully first.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for Hytec 8515/8516 module
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to the comments in the carrier driver file.

Database definition file

Database definition file is: DLS8515.dbd which can be found in the src of the module. It contains:

```
function("DLS8515Configure")
function("DLS8516Configure")
function("DLS8515DevConfigure")
function("DLS8516DevConfigure")
function("DLS8515Display")
function("DLS8516Display")
variable(dls8515debug, int)
```

Building an Example Application

To build an example to test the 8515/8516 driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s).

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add calc, std and ipac modules:

  ```
  IPAC=$(SUPPORT)/ipac/ipac-2.11
  DLS8515IP=$(TOP)/..
  ```

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += drvIpac.dbd
example_DBD += DLS8515.dbd

example_LIBS += Ipac
example_LIBS += DLS8515
```

- Build the application from example <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.

Configuration Shell Command for Start up Script

There are two sets configuration shell commands, one for configuring the IP module and one for configuring the individual UART port.

Module configuration commands

```
int DLS8515Configure(int card, int carrier, int vector, char *prefix)

int DLS8516Configure(int card, int carrier, int vector, char *prefix)
```

where:

card	card number	10 * slot + IP
carrier	carrier number	value returned by ipacAddHy8002()
vector	interrupt vector	192 - 255
poll	polling period	1 - x, 0 for interrupts
prefix	device name prefix	

UART configuration commands

```
int DLS8515DevConfigure(char *dev, int baud, int data, int stop, int
parity, int flow);

int DLS8516DevConfigure(char *dev, int baud, int data, int stop, int
parity, int flow, int tadelay, int duplex);
```

where:

*dev	device name
baud	baud rate. Valid value = 100, 400, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, 115200, 153600, 230400, 460800, 921600
data	data bit could. Valid value = 5, 6, 7, 8
stop	stop bit could. Valid value = 1, 2
parity	parity check. Valid value = N, E, O
flow	flow control. Valid value = N, S, H
tadelay	half duplex changing over delay time. Valid value 0 ~ 15

duplex full/half duplex. Valid value = 0, 1, where 0 for half duplex and 1 for full duplex.

Example:

```
DLS8515Configure(73, IPAC7, newInterruptVector(), "ab")
```

would configure the IP module in VME slot 7, IP slot D and create the vxWorks devices /ab/73/0 - /ab/73/7

The individual channels can be configured with asynSetOption or DLS8515DevConfigure which has the following syntax:

```
DLS8515DevConfigure("/ab/73/0", 57600, 7, 1, 'E', 'N')
```

Some notes

- Use the command DLS8515Display(int level) with a level of 0 or 1 for some internal information and statistics. This command spawns a low priority task so don't run it in your boot script.
- Always uses interrupts for both sending and receiving data.
- Uses a vxWorks buffer size of 256 for transmit and 32768 for receive.
- Uses an RX FIFO trigger level of 56 and a TX FIFO trigger level of 1.
- Creates a TX and RX process for each IP module.
- Latches errors and prints a single message until acknowledged by the user.
- Is not hot swappable.
- There is also a DLS8516Configure command for 422/485 devices. The most important difference between this driver and drvHy8515 is that in RS485 mode you always receive the characters you transmit. It is up to the user to handle this in their StreamDevice protocol file. This is a feature of the UART used on the Hytec IP module.
- The DLS8516Configure command has two additional arguments; these are the "Auto RS485 Half Duplex Direction Control Delay From TX to RX" value in bit time (0-15) when using the RTS# line, and the second is the full duplex (1) for RS422 or half duplex (0) for RS485.
- If you have high data rates you will see a few "interrupt: bad vme interrupt 0" messages. The 8515/8516 appears to be a bit slow at de-asserting its interrupt request line so the IOC sometimes thinks that there is a pending interrupt when it returns from the interrupt service routine.

9.Hy8512 Scaler EPICS Device Driver

General Information

Hy8512scaler driver is designed to suit all requirements of the EPICS standard scaler record (version 3.19 or later). It assumes one of the channels as time reference, the channel 0 although in this driver, you can literally define any channel as the time reference by settings in the Hy8512Configure start up script please see later.

The driver is defined as a single group of 16 channels. You can define each channel as either "simple" channel (Gx=N) or "preset" channel (Gx=Y) in the database. “simple” and “preset” channel concepts are defined in the EPICS scaler record document. Please refer to reference [7].

Hytec 8512 scaler can also be initiated by hardware strobe. Please see later the configuration shell command for detail settings. For hardware settings please refer to reference [15] and 8002 carrier card user manual [4].

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.

- sncseq-2.0.12 module from the EPICS website from here http://www-csr.bessy.de/control/SoftDist/sequencer/Installation.html. This is needed by the std-2-8 module next.
- std-2-8 which contains the scaler record module from EPICS website from here http://www.aps.anl.gov/bcda/synApps/std/std.html
- calc-2-8 from http://www.aps.anl.gov/bcda/synApps/calc/calc.html
- sscan-2-8 from http://www.aps.anl.gov/bcda/synApps/sscan/sscan.html
- devlib2 version 2.1 or later if porting RTEMS on IOC9010 blade
- RTEMS R4.9.4 or later if RTEMS is the operating system.

Build the module library

To build the module library,

- Before building the 8512 module, the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for sncseq-2.0.12 module and build the library
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for std-2-8 module and build the library
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for calc-2-8 module and build the library
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for sscan-2-8 module and build the library
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site for Hytec 8512 scaler module
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8512.dbd which can be found in the src of the module. It includes just two lines:

```
device(scaler,VME_IO,devHy8512,"Hy8512")
registrar(Hy8512Register)
```

Testing Database(s)

A testing database can be found in the example/Hy8512exampleApp/db directory named Hy8512.db. It provides support for using the standard EPICS scaler record.

Building an Example Application

To build an example to test the 8512scaler driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add calc, std and ipac modules:

```
CALC=$(SUPPORT)/calc-2-8
STD=$(SUPPORT)/std-2-8
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8512IP=$(TOP)/..
```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

```
cctvmeen/include
        /lib/linux-x86
```

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

```
CCTVMEEN=$(SUPPORT)/cctvmeen
```

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
Hy8512example_DBD += drvIpac.dbd
Hy8512example_DBD += std.dbd
Hy8512example_DBD += Hy8512.dbd

Hy8512example_LIBS += calc
Hy8512example_LIBS += Ipac
Hy8512example_LIBS += std
Hy8512example_LIBS += Hy8512
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
Hy8512example_DBD += epicspci.dbd
Hy8512example_DBD += epicsvme.dbd
Hy8512example_LIBS += epicspci
```

NOTE: to include this epicsvme appears to be a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy Hy8512.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += Hy8512.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPaths file is set up properly.

- Build the application from example <TOP>
- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.
- Go to <TOP>/example/display folder. Execute medm command shown below:

```
medm -x -macro "P=HYTEC:,S=SCALER1" scaler16.adl
```

This will load the medm test screen. Click on "More" button to extend the screen. If you hit the Count button, after about 10 seconds, the scaler will stop since channel 0 is set to count 10 seconds with internal clock 10MHz. You can see all the variable changes.

When you use the scaler16.adl medm screen, changing a channel's Gate setting Gn from "N" to "Y", the scaler record automatically defaults the channel preset value PRn to 1000. You can change it to your need. This change take effect immediately as you can see on the screen.

Whereas when you change Gn from "Y" to "N", the medm screen doesn't zero the PRn field until a Count (CNT) command is issued. This is because that the scaler record was processed in a way that it only invokes notification to the device support when Gn = 1, not on Gn = 0. The device support has no way of knowing the change until the CNT command is sent. But this doesn't affect the scaler function since in my driver I guarantee the proper PRn values being written to the correct channels as per the latest Gn settings before arming the scaler (start counting) every time. In the checking, if a channel's Gn is "N", I will zero its PRn and notify the client end interest as well. You can observe this by changing a Gn from "Y" to "N". The PRn value stays. Then click on "Count" button, the PRn is zeroed.

Configuration Shell Command for Start up Script

The Hy8512Configure routine is defined as below.

```
Hy8512Configure(int cardnum, int carrier, int ipslot, int intnum, int
            clockbit, int verbose, int extarm)
```

Where:

cardnum	card number in the system
carrier	carrier serial number. Normally set to 0 unless there are multiple carriers
ipslot	the IP slot on the carrier. Can be 0 ~ 5 for IOC9010 as referring to slot A ~ F
intnum	interrupt vector
clockbit	define the channel to be used as time reference. Value 0 ~ 15 representing channel 0 or 1 or … 15 to be used as time reference.

verbose printing messages during the loading process if set to 1. Set to 0 the loading will keeps quiet.

extarm external arming and start when set to 1. If it is set to 0, the scaler will be armed (and started) by software arming.

Example: assuming 8512 is in slot A, card number 18, vector 0x58, channel 0 is the time reference and shout loudly.

```
Hy8512Configure(18, 0, 0, 0x58, 0, 1, 0)
```

This configures the scaler as

card number 18

carrier serial number 0

IP slot A

interrupt vector 0x58,

bit 0 or channel 0 is used as time reference

print debug messages

use internal arming.

Start up Script Example

Below is an example of start up script for Linux IOC.

```
#!../../bin/linux-x86/Hy8512example

## You may have to change Hy8512example to something else
## everywhere it appears in this file

< envPaths

cd ${TOP}

## Register all support components
dbLoadDatabase "dbd/Hy8512example.dbd"
Hy8512example_registerRecordDeviceDriver pdbbase

# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")
```

```
# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")

# Hy8512Configure(cardnum, carrier, ipslot, intnum, clockbit, verbose, extarm)
Hy8512Configure(18, 0, 0, 0xC8, 0, 1, 0)

## Load record instances
#####simple db
#dbLoadRecords "db/Hy8512.db"
dbLoadRecords "db/Hy8512.db","P=HYTEC:,S=SCALER1,OUT=#C18 S1
@,DTYP=Hy8512,FREQ=10000000"

cd ${TOP}/iocBoot/${IOC}
iocInit
dbl
```

10. Hy8522 Histogram Scaler EPICS Device Driver

General Information

8522 scaler has 4 modes:

- normal histogram
- coincidence histogram
- straight scaler with memory
- prescaler mode (to suit the scaler record).

Each mode has its own initialisation routine. There is also a generic init routine for all:

int Hy8522AsynInit(char *portName, int vmeSlotNum, int ipSlotNum, int vectorNum,
int freq, int sourceMask, int hwtrigger, int hwreset)

where:
portName: asyn port name
carrierNum: carrier index number when adding a carrier card by ipacAddHy8002 call
ipSlotNum: IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F),
vectorNum: interrupt vector (0 = find one for me),
freq: For internal clock. 0=25MHz, 1=50MHz, 2=100MHz, 3=200MHz
sourceMask: bit mask for channel clock source. 0: external. 1: internal defined by freq param
hwtrigger: 1 = enable hardware trigger, 0 = only software trigger
hwreset: 1 = allow hardware reset, 0 = only software reset

The package comes with an example under TOP/example folder.

1) Normal histogram mode. In this mode, user defines number of gates (bins), number of cycles and time interval and time unit if it is time controlled advancing. The bin advance can be also done by external hardware pulses. In hardware advancing case, interval setting is the number of pulses to advance.

The returned waveform value for each bin can be set to accumulate all previous bins. This is done by the last parameter ‘accumulate’ if set. Default is normal histogram, i.e. not accumulation.

A). Bin advancing by time. Once triggered, the counters count for a period of time set by the gate interval setting. At the end of the interval, it saves the counting to the first memory location (first bin) then starts next bin counting. Again, at the end of the second interval, it saves data to the second

memory location and starts the third bin and so forth until the number of gates has been reached and the counting stops. This is one cycle. Next trigger starts the first bin again, at the end of the interval it adds the counting to the first memory location and starts the second bin and so forth. This goes on and on until the number of cycles has been reached. Each channel also has a totaliser that accumulates all counting for that channel.

The data can be read out by a waveform record. The number of elements is the number of gates + 1, where the last data is the totaliser counting of that channel.

To setup this mode, apart from the generic init routine, use the specific routine below:

int Hy8522HistogramMode(char *portName, int gateIntv, int timeunit, int nocycles, int nogates,
int mask, int extadvance, int accumulate)

where:

portName:	asyn port name
gateIntv:	The gate interval as below: If timeunit = 0, i.e. 1ms, this defines the interval in mini-second If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
timeunit:	Define interval time unit. 0 = 1ms, 1 = 100us
nocycles:	Define the number of cycles. If it is set to 0, the scaler doesn't do anything.
nogates:	Define the number of gates (bins), i.e. How many gates in a cycle. Each gate stores counting of pulses in one memory location. Next cycle adds up to the same locatoin to form histogram.
mask:	bit mask to enable/disable channels. 0 = enable, 1 = disable.
extadvance:	0, i.e. time advancing
accumulate:	0, normal histogram values. = 1, each bin also accumulates all previous bins

Setup example:

```
Hy8522AsynInit("SCALER8522", 0, 4, 88, 0, 0xFFFF, 1, 0 )
Hy8522HistogramMode("SCALER8522", 1000, 0, 4, 6, 0x0000, 0, 1)
```

For database example please refer to 8522.db file.

Once the ioc is loaded, either use soft trigger or hardware trigger to start the counting. Soft trigger can be issued by record:

```
caput CARD1:SOFTTRIGGER:OUT 1
```

To monitor the scaler record examples in the db file:

```
camonitor CARD1:COUNTER0:IN          -- to monitor the counter0 on the fly
camonitor CARD1:HISTOGRAM0:IN        -- to view histogram in memory
camonitor CARD1:INTRHISTOGRAM0:IN    -- to view histogram when cycles finish
```

Alternatively, user can use the edm screen in example/exampleApp/op/edl folder to test.

```
edm -x -m "P=CARD1:" example.edl
```

or use the CSS screen 8522.opi in the same folder to test it.

When all cycles finish, an interrupt is generated. The driver populates the I/O Intr float64 waveform records (INTRHISTOGRAM in the example database).

There is a command (by using record CARD1:RESTART:OUT) to control the restart behaviour. There are 4 types of restarts.

- caput CARD1:RESTART:OUT 0

  This defines a single shot scenario, i.e. after all cycles, subsequent triggers wouldn't trigger the test again. To re-enable it, set CARD1:RESTART:OUT to either 1 or 2 or 3. All records' data is maintained.

- caput CARD1:RESTART:OUT 1

  (Default) this defines continuous mode, i.e. after all the cycles, next trigger will start the whole cycles again and the data is added to the bins. All records' data is maintained.

- caput CARD1:RESTART:OUT 2

  This command will reset the scaler, i.e. clear all counters to 0.

- caput CARD1:RESTART:OUT 3

  This is the same as 2, i.e. reset scaler and clear all counters but it is done automatically after the last cycle. In this case, the normal waveform records (such as CARD1:HISTORGRAM0:IN etc) will read 0 after the reset. User can monitor the data by using "Intr I/O" waveform record like CARD1:INTRHISTOGRAM0:IN for example.

B). Bin advancing by external hardware pulses. This mode works similar to the time controlled advancing apart from the actual advancing is done by external pulses from the external trigger line.

The gate interval setting now sets the number of pulses that used for memory advancing control. At the beginning of each cycle (Note, not each bin), a trigger pulse is needed to start the counting. Once started, the scalers are counting until the number of pulses set by the interval parameter has been reached. Also, the last pulse of the sequence will save counting to the first bin (first memory location) and kick off the next bin and so forth. When the number of gates has been reached, a cycle is finished. At this point, it needs another trigger pulse to start the second cycle. Then it repeats till the number of cycles has been reached.

The setup of this mode is similar to the time advancing apart from the interval setting which is now the number of pulses for advancing. Also the extAdvance is set to 1.

Setup example:

```
Hy8522AsynInit("SCALER8522", 0, 4, 88, 0, 0xFFFF, 1, 0 )
Hy8522HistogramMode("SCALER8522", 10, 0, 4, 6, 0x0000, 1, 0)
```

For the rest of description please refer to time advancing above.

2) Coincidence histogram mode differentiates itself from normal histogram mode only by the counting mechanism. The normal histogram mode counts by pulse input, whereas the coincidence histogram mode counts by matching the pattern on the 16 input lines.

Each channel has a pattern register. The channel only counts when the 16 input lines match this set pattern. All the rest are exactly the same as the normal histogram mode such as advancing by either time or external pulses.

To setup this mode, apart from the generic init routine, use the specific routine below:

```
int Hy8522CoincidenceMode(char *portName, int gateIntv, int timeunit, int nocycles, int nogates,
                int mask, int extadvance, int accumulate)
```

where:

portName:	asyn port name
gateIntv:	When extadvance setting is 0 , this is the gate interval as below: If timeunit = 0, i.e. 1ms, this defines the interval in mini-second If timeunit = 1, i.e. 100us, this defines the interval in 100us steps. When extadvance = 1, it is number of pulses to advance the memory location
timeunit:	Define interval time unit. 0 = 1ms, 1 = 100us
nocycles:	Define the number of cycles. If it is set to 0, the scaler doesn't do anything.

nogates: Define the number of gates (bins), i.e. how many gates in a cycle. Each gate stores counting of pulses in one memory location. Next cycle adds up to the same locatoin to form histogram.
mask: bit mask to enable/disable channels. 0 = enable, 1 = disable.
extadvance: Advancing type. 0 = time advancing, 1 = external pulse advancing
accumulate: 0, normal histogram values. = 1, each bin also accumulates all previous bins

Also use two pattern init routines to set up the patterns.

int Hy8522AsynInitCoin0_7(char *portName, int coin0, int coin1, int coin2,
int coin3, int coin4, int coin5, int coin6, int coin7)

int Hy8522AsynInitCoin8_15(char *portName, int coin8, int coin9, int coin10,
int coin11, int coin12, int coin13, int coin14, int coin15)

where:
portName: asyn port name
coin0 ~ coin15: matching patterns for channel 0 ~ 15.

Setup example:

```
Hy8522AsynInit("SCALER8522", 0, 4, 88, 0, 0xFFFF, 1, 0 )
Hy8522CoincidenceMode("SCALER8522", 100, 0, 4, 6, 0x0000, 0, 0)

Hy8522AsynInitCoin1("SCALER8522", 0x1111, 0x2222, 0x3333, 0x4444, 0x5555, 0x6666,
0x7777, 0x8888 )
Hy8522AsynInitCoin2("SCALER8522", 0x9999, 0xAAAA, 0xBBBB, 0xCCCC, 0xDDDD,
0xEEEE, 0xFFFF, 0x0000 )
```

The rest are similar to the normal histogram mode. Please refer to previous section.

3) Straight scaler mode with memory. In this mode, user sets up the counting interval and number of cycles. Each trigger starts counting for the time set by the interval then save the counts at the end of the interval to one memory location. Nest trigger saves to the next memory location. This repeats till the number of cycles. At the end, an interrupt is generated.

To setup this mode, apart from the generic init routine, use the specific routine below:

int Hy8522StraightMode(char *portName, int gateIntv, int timeunit, int nocycles, int mask)

where:

portName: asyn port name
gateIntv: Define gate interval as below:
If timeunit = 0, i.e. 1ms, this defines the interval in mini-second
If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
Timeunit: Define interval time unit. 0 = 1ms, 1 = 100us
Nocycles: Define the number of trigger cycles. Up to 32K.
Mask: bit mask to enable/disable channels. 0 = enable, 1 = disable.

Note there is no external advancing for this mode.

Setup example:

```
Hy8522AsynInit("SCALER8522", 0, 4, 88, 0, 0xFFFF, 1, 0 )
Hy8522StraightMode("SCALER8522", 100, 0, 20, 0x0000)
```

Once the ioc is loaded, either use soft trigger or hardware trigger to start the bin counting. Soft trigger by record:

```
caput CARD1:SOFTTRIGGER:OUT 1
```

To start next bin, do trigger again.

To monitor the scalers:

```
camonitor CARD1:COUNTER0:IN                    -- to monitor the counter0 on the fly
camonitor CARD1:STRAIGHTSCALER0:IN             -- to view straight scaler memory values
camonitor CARD1:INTRSTRAIGHTSCALER0:IN -- to view straight scaler values when all
                                                  cycles finish
```

Alternatively, user can use the edm screen in example/exampleApp/op/edl folder to test.

```
edm -x -m "P=CARD1:" example.edl
```

or use the CSS screen 8522.opi in the same folder to test it.

When all cycles have finished, an interrupt is generated. The driver populates the I/O Intr float64 waveform records (INTRHISTOGRAM in the example database). To restart the process or test, the user can have 4 types of restarts. This can be defined by the value of CARD1:RESTART:OUT record in the example database.

```
- caput CARD1:RESTART:OUT   0
```

This defines a single shot scenario, i.e. after all the cycles, subsequent triggers wouldn't trigger the test again. To re-enable it, set CARD1:RESTART:OUT to either 1 or 2 or 3.

- caput CARD1:RESTART:OUT 1

(Default) this defines continuous mode, i.e. after all the cycles, next trigger will clear all memory data and start again.
- caput CARD1:RESTART:OUT 2

This restart command when issued will reset the scaler, i.e. it will clear all memory data to 0.

- caput CARD1:RESTART:OUT 3

This is the same as 2, i.e. reset scaler and clear all counters' memory data to 0 but it is done automatically after the last cycle in the interrupt service routine. In this case, the normal waveform records (such as CARD1:STRAIGHTSCALER0:IN etc) will read 0 after the reset. User can monitor the data by using "Intr I/O" waveform record like CARD1:INTRSTRAIGHTSCALER0:IN for example.

4) Preset scaler mode.

Preset scaler mode works exactly the same way as the scaler record (version 3.20 and above), i.e. channel 0 is always the timing control. It has two modes, normal counting and background counting; each channel (apart from channel 0 which will be always preset) can be set as either preset or simple counter by G2 ~ G16 in the scaler record; also, preset values can be passed by PR2 ~ PR16 etc.

Please note: channel 0 must be set as internal clock. If set as external clock in Hy8522AsynInit routine, the behaviour is undefined!

To setup this mode, apart from the generic init routine, use the specific routine below:

int Hy8522PresetMode(char *portName,int armMask)

where:
portName: asyn port name
armMask: Define ARM bit. Set to 1 to ARM the correspondent channel

The timing control of the first channel can be set by scaler record:

field(TP,"10") -- this defines counting for 10 seconds

Setup example:

```
Hy8522AsynInit("SCALER8522", 0, 4, 88, 0, 0xFFFF, 1, 0 )
Hy8522StraightMode("SCALER8522", 0xFFFF)                    //arm all
```

The preset scaler record example can be found in 8522_preset.db.

There are CSS screens in example/exampleApp/op/opi folder for testing:

```
-- load 8522.opi first
-- select Preset Scaler button.
```

Few notes:

-- Many settings can be set by configuration shell command discussed later. Also they can be altered at run time by command records. This includes changing 'nocycles', 'nogates', 'gateintv' etc by the following command records:

```
caput CARD1:CYCLES:OUT n              -- number of cycles
caput CARD1:GATES:OUT n               -- number of gates
caput CARD1:GATEINTERVAL:OUT n        -- gate interval. Unit is defined by
caput CARD1:TIMEUNIT:OUT n            -- interval time Unit. 0:1ms, 1:100us
caput CARD1:EN_HW_TRIGGER:OUT 0/1-- 1:enable hardware trigger, 0:only software
trigger
caput CARD1:EN_HW_RESET:OUT 0/1    -- 1:enable hardware reset, 0:only software reset
```

See more command records in 8522.db file.

-- Record below can be used for triggering the cycle via software:

```
caput CARD1:SOFTTRIGGER:OUT 1      -- software trigger
```

-- Few status monitoring is also available via records. These include:

```
caget CARD1:CUR_MEM_POINT:IN       -- to query the current pointer of memory writing
for basic scaler mode
caget CARD1:TRIGGERS_RCV:IN        -- number of triggers received
caget CARD1:SUPPORT:IN             -- this always returns 3. It means thr driver
support both continuous and trigger mode
```

caget CARD1:FIRMWARE_VERSION:IN -- this returns the IP card firmware version. 301 means version 3.1
caget CARD1:DRIVER_VERSION:IN -- this returns the driver version. 101 means version 1.0

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devlib2 version 2.1 or later if porting RTEMS on IOC9010 blade
- RTEMS R4.9.4 or later if RTEMS is the operating system.
- calc (ver 2-8 or later), std (ver 2-8 or later) modules are needed for preset scaler support.

Build the module library

To build the module library,

- Before building the 8522 module, the asyn driver, the ipac driver, calc and std modules have to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site

- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8522Asyn.dbd.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query data in all cases
"COIN"	-- [out] set up channel coincidence pattern
"ENABLEHWTRIGGER"	-- [out] set up enabling hardware trigger
"ENABLEHWRESET"	-- [out] set up enabling hardware reset
"GATEINTERVAL"	-- [out] set up gate interval
"NOCYCLES"	-- [out] set up number of cycles
"NOGATES"	-- [out] set up number of gates
"SOFTTRIGGER"	-- [out] software trigger
"INPUTMASK"	-- [out] set up input mask or ARM for preset scaler
"TIMEUNIT"	-- [out] set up time unit
"EXTADVANCE"	-- [out] set up bin advancing
"FREQUENCY"	-- [out] set up internal source frequency
"SOURCE"	-- [out] set up internal/external source
"RESTART"	-- [out] set restart type, 0:single shot, 1:continuous, 2:manual reset, 3:auto reset
"ADDUPHISTOGRAM"	-- [out] set eaveform returning type, 0:normal histogram, 1:each bin also accumulates all previous bins
"SCALER_RESET"	-- [out] reset preset scaler
"SCALER_CHANNELS"	-- [out] query channel numbers, preset scaler
"SCALER_READ"	-- [in] read scaler counters on the fly, preset scaler
"SCALER_READ_SINGLE"	-- [in] read single counter on the fly, preset scaler
"SCALER_PRESET"	-- [out] preset a counter, preset scaler
"SCALER_ARM"	-- [out] arm scaler, preset scaler

"SCALER_DONE"	-- [in] done flag reading for preset scaler
"MEMPOINTER"	-- [in] query current memory location for basic scaler mode
"NOTRIGGERS"	-- [in] query number of triggers received so far
"TRIGGERSTATE"	-- [in] query current trigger status
"FWVERSION"	-- [in] query IP card firmware version
"DRIVERVERSION"	-- [in] query driver software version
"SUPPORT"	-- [in] query driver support info

These function codes can be used for querying, controlling and monitoring the scaler data, status etc.

Note:

"DATA" can be used for querying COUNTER, HISTOGRAM, INTRHISTOGRAM and INTRBASIC records. INTRHISTOGRAM and INTRBASIC records are only valid at the end of experiment, i.e. when there is an interrupt generated.

Example database records: use one of the following at a time according to the mode.

```
dbLoadRecords("db/8522.db")
```

or

```
dbLoadRecords("db/8522_preset.db","P=CARD1, S=SCALER1, PORT=SCALER8522, DTYP=Asyn Scaler, OUT=@asyn(SCALER8522), FREQ=25000000")  #only for preset scaler
```

Query data:

```
record(ai, "$(P):COUNTER0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(PREC, "3")
}

#for normal histogram mode
record(waveform,"$(P):HISTOGRAM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynFloat64ArrayIn")
        field(INP,"@asyn($(PORT) 0) DATA")
        field(NELM,"30")
        field(FTVL,"DOUBLE")
}
```

```
#for normal histogram mode at the end of the whole cycles
record(waveform,"$(P):INTRHISTOGRAM0:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP,"asynFloat64ArrayIn")
        field(INP,"@asyn($(PORT) 0) DATA")
        field(NELM,"10")
        field(FTVL,"DOUBLE")
}

#for straight scaler mode
record(waveform,"$(P):STRAIGHTSCALER0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) DATA")
        field(NELM,"25")
        field(FTVL,"ULONG")
}
```

Controls:

```
record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}

record(longout, "$(P):CYCLES:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) NOCYCLES")
}

record(longout, "$(P):GATEINTERVAL:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) GATEINTERVAL")
}

record(longout, "$(P):RESTART:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) RESTART")
}
```

Status:

```
record(ai,"$(P):FIRMWARE_VERSION:IN") {
   field(DTYP,"asynInt32")
   field(INP,"@asyn($(PORT) 0) FWVERSION")
   field(SCAN, "1 second")
```

```
}
```

.....

Building an Example Application

To build an example to test the 8512scaler driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

  CALC=$(SUPPORT)/calc/calc-2-8
  STD=$(SUPPORT)/std/std-2-8
  ASYN=$(SUPPORT)/asyn/asyn4-14
  IPAC=$(SUPPORT)/ipac/ipac-2.11

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

  ```
  EPICSPCI=$(SUPPORT)/devlib2-2.0
  ```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

  cctvmeen/include
  /lib/linux-x86

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

  CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

  ```
  example_DBD += asyn.dbd
  example_DBD += drvIpac.dbd
  example_DBD += transformRecord.dbd
  ```

```
example_DBD += Hy8522Asyn.dbd
example_DBD += std.dbd

example_LIBS += calc
example_LIBS += std
example_LIBS += Hy8522ipAsyn
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme appears to be a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```
DB += scaler_8522.db

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPaths file is set up properly.

- Build the application from example <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.

- There are test CSS screens in example/exampleApp/op/edl folder. Copy these to

CSS working folder to test the ioc.

Configuration Shell Command for Start up Script

As mentioned before, there is one generic init routine plus 4 mode specific init routines for the configuration (additional two coincidence pattern setting init routines for coincidence mode).

Generic Configuration

```
int Hy8522AsynInit(char *portName,
                   int carrierNum,
                   int ipSlotNum,
                   int vectorNum,
                   int freq,
                   int sourceMask,
                   int hwtrigger,
                   int hwreset)
```

where:

(1) portName	asyn port name
(2) carrierNum	carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum	IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum	Interrupt Vector (0 - Find One ?)
(5) freq	For internal clock. 0=25MHz, 1=50MHz, 2=100MHz, 3=200MHz
(6) sourceMask	bit mask for channel clock source. 0=external. 1=internal defined by freq param
(7) hwtrigger	0 = no hardware trigger, 1 = allow hardware trigger
(8) hwreset	0 = no hardware reset, 1 = allow hardware reset

Normal Histogram Mode Configuration

```
int Hy8522HistogramMode(char *portName,
                        int gateIntv,
                        int timeunit,
                        int nocycles,
                        int nogates,
                        int mask,
                        int extadvance
                        int accumulate)
```

where:

(1) portName	asyn port name

(2) gateIntv	The gate interval as below: If timeunit = 0, i.e. 1ms, this defines the interval in mini-second If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
(3) timeunit	Define interval time unit. 0 = 1ms, 1 = 100us
(4) nocycles	Define the number of cycles. If it is set to 0, the scaler doesn't do anything.
(5) nogates	Define the number of gates (bins), i.e. how many gates in a cycle. Each gate stores counting of pulses in one memory location. Next cycle adds up to the same locatoin to form histogram.
(6) mask	bit mask to enable/disable channels. 0 = enable, 1 = disable.
(7) extadvance	Define advancing mechanism. 0 = time advancing, 1 = external pulse advancing
(8) accumulate	0 = normal histogram, 1 = each bin also accumulates all previous bins

Coincidence Histogram Mode Configuration.

```
int Hy8522CoincidenceMode(char *portName,
                          int gateIntv,
                          int timeunit,
                          int nocycles,
                          int nogates,
                          int mask,
                          int extadvance,
                          int accumulate)
```

where:

(1) portName	asyn port name
(2) gateIntv	The gate interval as below: If timeunit = 0, i.e. 1ms, this defines the interval in mini-second If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
(3) timeunit	Define interval time unit. 0 = 1ms, 1 = 100us
(4) nocycles	Define the number of cycles. If it is set to 0, the scaler doesn't do anything.
(5) nogates	Define the number of gates (bins), i.e. How many gates in a cycle. Each gate stores counting of pulses in one memory location. Next cycle adds up to the same locatoin to form histogram.
(6) mask	bit mask to enable/disable channels. 0 = enable, 1 = disable.
(7) extadvance	Define advancing mechanism. 0 = time advancing, 1 = external pulse advancing
(8) accumulate	0 = normal histogram, 1 = each bin also accumulates all previous bins

Coincidence Pattern for Channel 0 ~ 7

```
Hy8522AsynInitCoin1(char *portName,
```

```
                                int coin0,
                                int coin1,
                                int coin2,
                                int coin3,
                                int coin4,
                                int coin5,
                                int coin6,
                                int coin7)
```

where:

(1) portName	asyn port name
(2) coin0	coincidence pattern for channel 0
(3) coin1	coincidence pattern for channel 1
(4) coin2	coincidence pattern for channel 2
(5) coin3	coincidence pattern for channel 3
(6) coin4	coincidence pattern for channel 4
(7) coin5	coincidence pattern for channel 5
(8) coin6	coincidence pattern for channel 6
(9) coin7	coincidence pattern for channel 7

Coincidence Pattern for Channel 8 ~ 15

```
Hy8522AsynInitCoin2(char *portName,
                                int coin8,
                                int coin9,
                                int coin10,
                                int coin11,
                                int coin12,
                                int coin13,
                                int coin14,
                                int coin15)
```

where:

(1) portName	asyn port name
(2) coin8	coincidence pattern for channel 8
(3) coin9	coincidence pattern for channel 9
(4) coin10	coincidence pattern for channel 10
(5) coin11	coincidence pattern for channel 11
(6) coin12	coincidence pattern for channel 12
(7) coin13	coincidence pattern for channel 13
(8) coin14	coincidence pattern for channel 14

(9) coin15 coincidence pattern for channel 15

Example:

```
Hy8522AsynInit("SCALER8522", 0, 0, 88, 0, 0xFFFF, 1, 0 )
Hy8522HistogramMode("SCALER8522", 100, 0, 4, 6, 0x0000, 0, 1)
Hy8522AsynInitCoin1("SCALAR8522", 0x1111, 0x2222, 0x3333, 0x4444, 0x5555, 0x6666,
0x7777, 0x8888 )
Hy8522AsynInitCoin2("SCALAR8522", 0x9999, 0xAAAA, 0xBBBB, 0xCCCC, 0xDDDD,
0xEEEE, 0xFFFF, 0x0000 )
```

This configures the 8522 card with
port name: "SCALAR8522"
carrierNum = 0
IP slot = 0 (slot 'A')
interrupt vector = 0x88
internal clock = 25MHz
all channels use internal clock
allow hardware trigger
no hardware reset
each bin also accumulates all previous bins

gate interval is 100ms
time unit = 1ms
number of cycles (actaully number of bins) is 4
number of gates is 6
use all channels
time interval advancing

The following coincidence patterns are actually not used in this mode.
channel 0 coincidence pattern is 0x1111
channel 1 coincidence pattern is 0x2222
channel 2 coincidence pattern is 0x3333
channel 3 coincidence pattern is 0x4444
channel 4 coincidence pattern is 0x5555
channel 5 coincidence pattern is 0x6666
channel 6 coincidence pattern is 0x7777
channel 7 coincidence pattern is 0x8888
channel 8 coincidence pattern is 0x9999
channel 9 coincidence pattern is 0xAAAA
channel 10 coincidence pattern is 0xBBBB

channel 11 coincidence pattern is 0xCCCC
channel 12 coincidence pattern is 0xDDDD
channel 13 coincidence pattern is 0xEEEE
channel 14 coincidence pattern is 0xFFFF
channel 15 coincidence pattern is 0x0000

Straight Scaler Mode Configuration

```
int Hy8522StraightMode(char *portName,
                       int gateIntv,
                       int timeunit,
                       int nocycles,
                       int mask)
```

where:

(1)	portName	asyn port name
(2)	gateIntv	Define gate interval as below: If timeunit = 0, i.e. 1ms, this defines the interval in mini-second If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
(3)	timeunit	Define interval time unit. 0 = 1ms, 1 = 100us
(4)	nocycles	Define the number of trigger cycles. Up to 32K.
(5)	mask	bit mask to enable/disable channels. 0 = enable, 1 = disable.

Preset Scaler Mode Configuration

```
int Hy8522PresetMode(char *portName,
                     int armMask)
```

where:

(1)	portName	asyn port name
(2)	armMask	Define ARM bit. Set to 1 to ARM the correspondent channel

Start up Script Example

The following example is for an IOC that uses Linux on Hytec IOC9010 blade.

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
```

```
< envPaths

cd ${TOP}

epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")
epicsEnvSet(EPICS_CA_AUTO_ADDR_LIST, "NO")
epicsEnvSet(EPICS_CA_ADDR_LIST, "172.23.81.195")

## Register all support components
dbLoadDatabase("dbd/example.dbd",0,0)
example_registerRecordDeviceDriver pdbbase

#carrier card configuration
# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1,IPCLCKE=32")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")

# For VME/Linux with Concurrent processor
#ipacAddHy8002Concurrent("2,2")

#int Hy8522AsynInit(
#  char *portName,  /* "SCALER8522" */
#  int carrierNum,          /* 0 */
#  int ipSlotNum,   /* 0 ~ 5 for slot 'A' to 'F' */
#  int vectorNum,   /* 88 */
#  int freq,                /* internal clock. 0: 25MHz, 1:50MHz, 2:100MHz, 3:200MHz */
#  int sourceMask,          /* bi mask for clock source. 0: external. 1: internal defined by freq *////
#  int hwtrigger,   /* 0: no hardware trigger, 1: allow hardware trigger */
#  int hwreset)   /* 0: no hardware reset, 1: allow hardware reset */
Hy8522AsynInit("SCALER8522", 0, 0, 88, 0, 0xffff, 1, 0 )

#int Hy8522HistogramMode(
#  char *portName,        /* asyn port name
#  int gateIntv,   /* When extadvance setting is 0 , this is the gate interval as below:
#                   If timeunit = 0, i.e. 1ms, this defines the interval in mini-second
#                   If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
#                   /* When extadvance = 1, it is number of pulses to advance the memory location
#  int timeunit,   /* Define interval time unit. 0 = 1ms, 1 = 100us
#  int nocycles,  /* Define the number of cycles. If it is set to 0, the scaler doesn't do anything.
#  int nogates,    /* Define the number of gates (bins), i.e. How many gates in a cycle. Each gate
#                   stores counting of pulses in one memory location. Next cycle adds up to
```

```
#                   the same locatoin to form histogram.
#  int mask,        /* bit mask to enable/disable channels. 0 = enable, 1 = disable.
#  int extadvance, /* Memory advance control. 0 = advanced by interval timer, 1 = advanced by external
hardware pulses
#  int accumulate)          /* 0 = normal histogram, 1 = each bin also accumulates all previous bins
#Hy8522HistogramMode("SCALER8522", 1000, 0, 4, 6, 0x0000, 0, 1)   #uncomment this for normal
histogram mode

#int Hy8522CoincidenceMode(
#  char *portName,        /* asyn port name
#  int gateIntv,   /* When extadvance setting is 0 , this is the gate interval as below:
#                   If timeunit = 0, i.e. 1ms, this defines the interval in mini-second
#                   If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
#                   /* When extadvance = 1, it is number of pulses to advance the memory location
#  int timeunit,   /* Define interval time unit. 0 = 1ms, 1 = 100us
#  int nocycles,  /* Define the number of cycles. If it is set to 0, the scaler doesn't do anything.
#  int nogates,    /* Define the number of gates (bins), i.e. How many gates in a cycle. Each gate
#                   stores counting of pulses in one memory location. Next cycle adds up to
#                   the same locatoin to form histogram.
#  int mask,                /* bit mask to enable/disable channels. 0 = enable, 1 = disable.
#  int extadvance,          /* Memory advance control. 0 = advanced by interval timer, 1 = advanced by external
hardware pulses
#  int accumulate)          /* 0 = normal histogram, 1 = each bin also accumulates all previous bins
#Hy8522CoincidenceMode("SCALER8522", 100, 0, 4, 6, 0x0000, 0, 0)  #uncomment this and the next two
lines for coincidence histogram mode
#Hy8522AsynInitCoin1("SCALER8522", 0x1111, 0x2222, 0x3333, 0x4444, 0x5555, 0x6666, 0x7777,
0x8888 )
#Hy8522AsynInitCoin2("SCALER8522", 0x9999, 0xAAAA, 0xBBBB, 0xCCCC, 0xDDDD, 0xEEEE,
0xFFFF, 0x0000 )

#int Hy8522StraightMode(
#  char *portName,        /* asyn port name
#  int gateIntv,   /* Define gate interval as below:
#                   If timeunit = 0, i.e. 1ms, this defines the interval in mini-second
#                   If timeunit = 1, i.e. 100us, this defines the interval in 100us steps.
#  int timeunit,   /* Define interval time unit. 0 = 1ms, 1 = 100us
#  int nocycles,  /* Define the number of trigger cycles. Up to 32K
#  int mask)       /* bit mask to enable/disable channels. 0 = enable, 1 = disable
#Hy8522StraightMode("SCALER8522", 100, 0, 20, 0x0000)                #uncomment this for straight scaler
mode


#int Hy8522PresetMode(
#  char *portName,        /* asyn port name
#  int armMask)            /* Define ARM bit. Set to 1 to ARM the correspondent channel
Hy8522PresetMode("SCALER8522", 0xffff);
```

```
#8522.db is for other modes, 8522_preset.db is for preset scaler mode. Use only one of them.
#dbLoadRecords("db/8522.db","P=CARD1,PORT=SCALER8522")
dbLoadRecords("db/8522_preset.db","P=SCALER, S=SCALER1, PORT=SCALER8522, DTYP=Asyn Scaler,
OUT=@asyn(SCALER8522), FREQ=25000000")

# set trace output level for asyn port "SCALER8522"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                0x01: error,
#                0x11: errors, warnings and debug
#                0x00: silent
asynSetTraceMask( "SCALER8522", 0, 0x00 )
# all driver level messages

iocInit()
dbl
```

11. Hy8401 8 Channel 16bit ADC EPICS Asyn Device Driver

General Information

8401 asyn driver provides three modes: continuous mode, trigger mode and gated mode.

Continuous Mode

In continuous mode, the ADC starts acquisition immediately after the IOC is initialised, i.e. it is enabled automatically at the beginning by setting the ENABLE record to 1 in the driver. User can stop this by setting ENABLE record to 0 at any time. Two important configuration arguments in the Init routine are: “average” and “samples”.

“average” is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes “average” number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1.

“samples” is used for waveform records which specifies the maximum samples possible to be returned to the records. The real number returned is specified by the NORD field at run time.

Returned data can be either integer or floating. Integer data is the raw ADC values and floating data is converted to voltage values (either +/-10V or +/-5V).

Continuous mode can be stop/start by the ENABLE command at any time.

Trigger Mode

In trigger mode, the ADC doesn’t start until it is enabled by the ENABLE record command plus either a software trigger or a hardware trigger. And once triggered, the ADC only collects “samples” + “offset” number of samples then stops.

“offset” is the number of samples at the beginning of trigger that it is less interest to the user so that they can be ignored for the data records calculation or collection. This asynDriver doesn’t support negative “offset” for trigger mode.

“samples” defines the number of interest points the ADC should acquire after a trigger and the offset.

“average” is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes “average” number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. There are two flags: overflow and averageOverflow that reflect some abnormities. When the following conditions occur, the flags are set.

- First of all, “offset” + “samples” cannot exceed 64K.
- Whenever the setting of either the “samples” or the “offset” is set, a check is carried out. If “samples” + “offset” exceeds 64k, (64k – “offset”) is used for “samples” and overflow flag is set.
- “average” cannot exceed “samples” + “offset”. If it does, averageOverflow flag is set and “average” is set to “samples” + “offset”.
- “offset” can also be negative (i.e. pre-trigger sampling).

For polled ai records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- Whenever N is less than “offset”, averageOverflow flag is set. Also if N is less than “average”, all data collected as far is used to do the averaging. If N is greater than “average”, the most recent “average” number of readings will be used.
- When N is greater than “offset” and (N - “offset”) is greater than or equals to “average”, the most recent “average” number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from “offset” to N is used for averaging and the averageOverflow flag is set.

For polled waveform records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- If N is less than or equals to “offset”, all data collected as far is returned. NORD is set to N.
- If N is greater than “offset”, N – “offset” number of readings is returned and NORD is set to N – “offset”.

For callback ai records:

- When “average” exceeds “samples”, “samples” number of data acquired is used for averaging. The averageOverflow flag is set.

Data returned can be either integer or floating. Integer data gives the raw ADC value and floating data gives converted voltage value (+/-10V or +/-5V).

Gated Mode

In gated mode, the ADC doesn’t acquire data until the ADC is enabled and the hardware inhibit line is de-asserted. And the ADC will be stopped when the hardware inhibit line is asserted or the ADC is disabled. In this mode, the hardware inhibit line functions as a gate to control the ADC.

“samples” setting has no meaning in gated mode.

“average” is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes “average” number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. The overflow and averageOverflow reflect abnormities of the following conditions.

- For gated mode, the ADC starts acquisition after it is initialised to registers but it doesn't store data to memory hence it doesn't serve any gated mode EPICS records until the gate is lifted. At start, the user needs to make sure that the hardware inhibit line is asserted (high). It would otherwise populate the EPICS records once it is enabled.
- "offset" must be less than 64K.
- "average" shouldn't exceed 64k.

For both polled and callback ai records, assuming at a certain point after the gate opens the ADC has collected "N" number of readings.

In the case of a positive "offset"

- If N is less than "offset", averageOverflow flag is set. Also if N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings is used.
- If N is greater than "offset" and (N - "offset") is greater than or equals to "average", the most recent "average" number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from "offset" to N is used for averaging and the averageOverflow flag is set.

In the case of a negative "offset"

- If N is greater than absolute "offset" value, if "average" is also greater than absolute "offset" value, most recent "offset" readings will be used for averaging and the averageOverflow flag is set. If "average" is less than absolute "offset" value, most recent "average" number of samples will be used and the averageOverflow flag is cleared.
- If N is less than absolute "offset" value, averageOverflow flag is set. If N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings is used.

For both callback and polled waveform records, assuming at a point or at the end of the gate the ADC has collected "N" number of readings.

In the case of a positive "offset"

- If N is greater than "offset", (N – "offset") samples are returned starting from "offset".
- Otherwise all data collected is returned.

In the case of a negative "offset"

- If N is greater than absolute "offset" value, "offset" number of samples are returned starting from N + "offset" (note here "offset" is negative).
- Otherwise all data collected is returned.

"offset" is the number of samples at the beginning of gate that it is less interest to the user so that they can be ignored for the data records calculation or collection. If not needed, "offset" can be set to 0. If "offset" is

positive number, the collecting point starts from the “offset” and till the end of the gated period. If “offset” is negative, the collection starts from the gated end point and take “offset” number of data backwards.

To enable any mode to work, a “ENABLE” command must be issued first.

For trigger and gated mode, “ENABLE” command means the ADC is ready and wait either for trigger or gate lifting. Once it is triggered or a gate is lifted, the ADC saves the samples to the memory until the number of samples reaches the settings (in trigger mode) or the gate is closed (in gated mode). It then stops and clears the ENABLE setting. To be able to start it again by the following trigger, the user needs to set ENABLE to 1 again. This ensures one trigger or one gate only scenario. To be able to trigger the ADC continuously by a sequence of triggers or gates, set REENABLE record to 1 after setting ENABLE record to 1.

The mode, samples, average, offset, clock rate, using external clock, range setting etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current memory pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- EPICS core R3.14.8.2 or later.
- RTEMS R4.9.4 or later.

Build the module library

To build the module library,

- Before building the 8401 module, the asyn driver and the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8401ipAsyn.dbd which is located in the src folder of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query data for FastSweep records
"GENDATA"	-- [in] query normal data
"SCAN_PERIOD"	-- [in] query scanning period in second
"SETAVERAGE"	-- [out] set average online
"SETSAMPLE"	-- [out] set samples online
"SETMODE"	-- [out] set mode online
"SETOFFSET"	-- [out] set offset online
"ENABLE"	-- [out] set/clear enable
"SOFTTRIGGER"	-- [out] software trigger
"REENABLE"	-- [out] set/clear reenable
"CLEARBUFFER"	-- not implemented
"SETCLOCKRATE"	-- [out] set clock rate online
"SETEXTCLOCK"	-- [out] set internal/external clock online

"AVERAGEOVERFLOW"	-- [in]query average overflow state
"OVERFLOW"	-- [in]query overflow state
"BUFFERCOUNT"	-- not implemented
"GATETRIGGERSTATE"	-- [in]query trigger/gated mode state
"SUPPORT"	-- [in]query driver support info

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"GENDATA" can be used for querying normal ADC data of types:
raw ADC data in integer
converted voltage ADC data in floating
waveform ADC data array in raw integer
waveform ADC data array in floating voltage
the "field(SCAN, xxx)" can be either " x second" or "I/O Intr".

Example database records:

```
dbLoadRecords("db/example.db")

record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNEL1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
```

```
}

record(waveform,"$(P):WAVEFORM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) GENDATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}
```

.....

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8401 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8401IP=$(TOP)/..
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the “include” sub-directory, it is the include header file: vme_api_en.h
In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8401ipAsyn.dbd

example_LIBS += Hy8401ipAsyn
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPaths file is set up properly.

- Build the application from <TOP>

- Modify stexample.src in iocBoot/iocexample as per next section and run the start up script from here.

Configuration Shell Command for Start up Script

The configuration ioc shell commands have two functions. Yet the second is not used. It was a legacy from the old driver.

int Hy8401ipAsynInit(char *portName,
int vmeSlotNum,
int ipSlotNum,
int vectorNum,
int samples,
int average,
int offset,
int mode,
int clockRate,
int extClock,
int fastADC)

Where:
(1) portName asyn port name
(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (0 - Find One ?)
(5) samples number of samples (not applicable in gated modes)
(6) average number of readings to SUM for average
(7) offset Trigger mode: Offset from trigger point to first ADC reading to return
Gated mode: Offset from the start (or end if negative) of the gated
period to the ADC readings to return
Continuous: Not applicable
(8) mode 0 = continuous, 1 = trigger, 3 = gated mode
(9) clockRate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz.

(10) extClock 0 = internal, 1 = extrenal
(11) fastADC flag to say if the ADC is running at fast speed for normal use.
=1 fast, =0 slow for MCA & EPID records

int Hy8401ipAsynConfig(char *portName,
int aiType,
int range,
int firstChan,
int lastChan,
int chanBuffSize);

Where:
(1) portName asyn port name
(2 The other parameters have no meaning

Example:

```
Hy8401ipAsynInit("Hy8401", 3, 0, 10000, 100, 0, 1, 15, 0, 1)
#Hy8401ipAsynConfig("Hy8401", 0, 1, 0, 7, 100)
```

This configures the 8401 card with
port name: "Hy8401"
carrierNum = 3
IP slot = 'A'
samples = 10000
average = 100
offset = 0
mode = trigger
scanning rate = 100kHz
clock source = internal
fastADC = yes

Start up Script Example

The following example is for an IOC that uses VxWorks5.5, MVME5500 processor board.

```
#!$(INSTALL)/bin/vxWorks-ppc604_long/example
cd "/dls_sw/work/R3.14.8.2/support/Hy8401ip-asyn/2-2/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
```

```
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


############################################################
#                  Carrier Card Configuration
############################################################
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel")
# ARGS                        8002/8003/8004
#   ID -- VME slot                  2~21
#   INTLevel -- INT level.          0~7
#==========================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                        IOC9010      PCIe6335    uTCA
#   ID -- carrier ID           99         carrier ID  carrier ID
#   INTLevel -- INT level.     0~7           0~7   0~7(not used, don't care)
#==========================================================

IPAC3 = ipacAddHy8002("3,2")

#int Hy8401ipAsynInit(char *portName,     - Hy8401
#  int carrierNo,             - IPAC3
#  int ipSlotNum,             - 1 (B)
#  int vectorNum,             - 10
#  int samples,               - 1000
#  int average,               - 10
#  int offset,                - 0
#  int scanMode,              - 1 (trigger mode)
#  int clockRate,             - 9 (1kHz)
#  int extClock,              - 0 (internal)
#  int fastADC)               - 1 (normal, not for mca & EPID)
Hy8401ipAsynInit("Hy8401", IPAC3, 0, 10, 1000, 10, 0, 1, 9, 0, 1)

#int Hy8401ipAsynConfig(const char *portName,
#  int aiType,
#  int range,
#  int firstChan,
```

```
#  int lastChan,
#  int chanBuffSize )
#Hy8401ipAsynConfig("Hy8401", 0, 1, 0, 7, 100)

# int initFastSweep(char *portName, char *inputName,
#                   int maxSignals, int maxPoints)
# portName   = asyn port name for this port
# inputName  = name of input port
# maxSignals = maximum number of input signals.
# maxPoints  = maximum number of points in a sweep.  The amount of memory
#              allocated will be maxPoints*maxSignals*4 bytes
#$(VXWORKS_ONLY)initFastSweep("8401Sweep1","Hy8401", 16, 10000)


##########
# Hytec 8402 DAC in IP site B of the IP carrier card in slot 10.
#$(VXWORKS_ONLY)Hy8402ipConfigure (302, IPAC3, 2, 11)

#initHy8402ipAsyn("DAC", 302)
##########

## Load record instances
dbLoadRecords("db/example.db","P=CARD1,PORT=Hy8401")
#dbLoadRecords("db/examplemca.db")
#dbLoadRecords("db/exampleepid.db")

# set trace output level for asyn port "Hy8401"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                     0x01: error,
#                     0x11: errors, warnings and debug
#                     0x00: silent
asynSetTraceMask( "Hy8401", 0, 0x00 )
# all driver level messages

iocInit()
```

12. Hy8411 16 Channel 16bit ADC with 256 FIFO Memory EPICS Device Driver

General Information

This 8411 asyn driver provides two modes: continuous mode and trigger mode.

In continuous mode, the ADC acquires samples from 16 channels continuously. The driver presents the samples in both raw data and voltage floating value for individual channels. In this mode, waveform records are invalid.

In trigger mode, once triggered, individual channel data (both raw and voltage) can be obtained the same way as continuous mode. The ADC also writes the samples to the device FIFO according to the clock rate setting. When the FIFO reaches 256 samples (for all 16 channels), it stops and raises an interrupt to tell the driver to populate the waveform records.

Both continuous and trigger mode need “ENABLE” command (via ENABLE record) to start/enable the ADC. Setting ENABLE record to 1 starts the ADC immediately in continuous mode. Yet it only enables the ADC in trigger mode and waits for trigger. Once it is triggered, the ADC saves the samples to the FIFO until the FIFO is full. It then stops and clears the ENABLE setting. To be able to trigger it again, need to set another ENABLE command. This ensures one trigger only scenario. To be able to trigger the ADC continuously by a sequence of triggers, set REENABLE record to 1 after setting ENABLE record to 1.

The mode, clock rate and using external clock etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current FIFO pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- EPICS core R3.14.8.2 or later.
- RTEMS R4.9.4 or later.

Build the module library

To build the module library,

- Before building the 8411 module, the asyn driver and the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8411Asyn.dbd which is located in the src folder of the module.

Testing Database(s)

asyn function code:

```
"DATA"              -- [in] query raw data
"FLOATDATA"         -- [in] query voltage data
"SETMODE"           -- [out] set mode online
"ENABLE"            -- [out] set/clear enable
"SOFTTRIGGER"       -- [out] software trigger
"REENABLE"          -- [out] set/clear reenable
"RESETFIFO"         -- [out] reset FIFO
"SETCLOCKRATE"      -- [out] set clock rate online
"SETEXTCLOCK"       -- [out] set internal/external clock online

"COUNTER"           -- [in] query FIFO pointer
"TRIGGERSTATE"      -- [in] query trigger mode state
"FWVERSION"         -- [in] query firmware version
"DRIVERVERSION"     -- [in] query driver version
"SUPPORT"           -- [in] query driver support info
```

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"DATA" can be used for querying ADC raw data:
single channel raw ADC data in integer. (SCAN, "1 second")
raw ADC waveform data for trigger mode. (SCAN, " I/O Intr ")

"FLOATDATA" can be used for querying ADC data in floating voltage:
single channel ADC data in voltage. (SCAN, "1 second")
waveform ADC data in floating voltage for trigger mode. (SCAN, " I/O Intr ")

“ENABLE” and “REENABLE”: When using as continuous mode, setting ENABLE to 1 starts the ADC. Setting it to 0 stops the ADC. In trigger mode, setting ENABLE to 1 allows only 1 trigger, i.e. once the ADC is triggered and finished, it won’t be triggered again unless you do another ENABLE. For continuous triggering, set ENABLE to 1 and also set REENABLE to 1.

Example database records:

```
dbLoadRecords("db/example.db")

record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(PREC, "3")
}
```

```
record(ai, "$(P):CHANNEL1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) DATA")
        field(PREC, "3")
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) FLOATDATA")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM8:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 8) DATA")
        field(NELM,"32")
        field(FTVL,"LONG")
}

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}
.....
```

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8411 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8411IP=$(TOP)/..
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the "include" sub-directory, it is the include header file: vme_api_en.h
In the "lib/linux-x86" sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8411Asyn.dbd

example_LIBS += Hy8411Asyn
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPaths file is set up properly.

- Build the application from <TOP>

- Modify stexample.src in iocBoot/iocexample as per next section and run the start up script from here.

Configuration Shell Command for Start up Script

The configuration ioc shell commands have two functions. Yet the second is not used. It was a legacy from the old driver.

int Hy8411AsynInit(char *portName,
int vmeSlotNum,
int ipSlotNum,
int vectorNum,
int mode,
int clockRate,
int extClock,
int range)

Where:
(1) portName asyn port name
(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (0 - Find One ?)
(5) mode 0 = normal continuous mode, 1 = trigger and FIFO mode

(6) clockrate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz.
16 = 160kHz
(7) extclock 0 = internal clock, 1 = external clock
(8) range 0 = 0~5V, 1 = 0~10V.

Note: range setting only tells the driver that the 8411 is fitted by manufacturer either with 0~5V or 0~10V. It is not a setting in the CSR register, i.e. the user cannot change the range, only inform the driver.

Example:

```
Hy8411ipAsynInit("ADC8411", 3, 0, 0x80, 1, 9, 0, 0)
```

This configures the 8411 card with
port name: "ADC8411"
carrierNum = 3
IP slot = 0 (slot 'A')
interrupt vector = 0x80
mode = trigger FIFO mode
scaning rate = 1kHz
clock source = internal
range is 0~5V

Start up Script Example

The following example is for an IOC that uses Linux on Hytec IOC9010 blade.

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
< envPaths

cd ${TOP}

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
```

```
# specific things. Alternatively, you can include an architecture
# specific file.
#$(VXWORKS_ONLY)ld < bin/$(ARCH)/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


# Run the configuration function once for each card in the IOC
# This is the function registered in registrarHy8314ip.c
#  Arguments should be something like:
#  * asyn port (string)
#  * VME slot number
#  * IP slot number
#  * - any other arguments that need to be used for configuration
#      at startup time.


# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1,IPCLCKB=32")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")

#int Hy8411AsynInit(
#  char *portName,  /* "ADC8411" */
#  int carrierNum,          /* 0 */
#  int ipSlotNum,   /* 0 */
#  int vectorNum,   /* 88 */
#  int mode,        /* 0 (continuous) */
#  int clockRate,   /* 9 (1kHz) */
#  int extClock)    /* 0 (internal) */
#  int range,       /* 1 (0~10V) */
Hy8411AsynInit("ADC8411", 0, 0, 88, 0, 9, 0, 1)

dbLoadRecords("db/example.db","P=CARD1,PORT=ADC8411")

# set trace output level for asyn port "ADC8411"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                  0x01: error,
```

```
#               0x11: errors, warnings and debug
#               0x00: silent
asynSetTraceMask( "ADC8411", 0, 0x00 )
# all driver level messages

iocInit()
```

13. Hy8413 16 Channel 16bit ADC EPICS Device Driver

General Information

8413 ADC is very similar to 8411 in the way of using FIFO memory to store continuous data samples. It has few differences as to the 8411:

- The FIFO memory is bigger. It has 16K for each channel.
- It has software selectable range setting either +/-5V or +/-10V.
- The ADC data can be either 2's complement or straight.
- It has software calibration.

Again, 8413 asyn driver provides two modes: continuous mode and trigger mode.

In continuous mode, the ADC acquires samples from 16 channels continuously. The driver presents the samples in both raw data and voltage floating value for individual channels. In this mode, waveform records have no meaning.

In trigger mode, once triggered, individual channel data (both raw and voltage) can be obtained the same way as continuous mode. The ADC also writes the samples to the device FIFO according to the clock rate setting. When the FIFO reaches 16K samples (for all 16 channels), it stops and raises an interrupt to tell the driver to populate the waveform records. The ADC won't start until next trigger.

Both continuous and trigger mode need "ENABLE" command (via ENABLE record) to start/enable the ADC. Setting ENABLE record to 1 starts the ADC immediately in continuous mode. Yet it only enables the ADC in trigger mode and waits for trigger. Once it is triggered, the ADC saves the samples to the FIFO until the FIFO is full. It then stops and clears the ENABLE setting. To be able to start it again by the following trigger, the user needs to set ENABLE to 1 again. This ensures one trigger only scenario. To be able to trigger the ADC continuously by a sequence of triggers, set REENABLE record to 1 after setting ENABLE record to 1.

The mode, clock rate, using external clock, range and data format etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current FIFO pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8413 module, the asyn driver and the ipac driver have to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At the 8413 <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8413Asyn.dbd which is located in the src folder of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query raw data
"FLOATDATA"	-- [in] query voltage data
"RANGE"	-- [out] set range
"FORMAT"	-- [out] set data format
"SETMODE"	-- [out] set mode online
"ENABLE"	-- [out] set/clear enable
"SOFTTRIGGER"	-- [out] software trigger
"REENABLE"	-- [out] set/clear reenable
"RESETFIFO"	-- [out] reset FIFO
"SETCLOCKRATE"	-- [out] set clock rate online
"SETEXTCLOCK"	-- [out] set internal/external clock online
"COUNTER"	-- [in] query FIFO pointer
"TRIGGERSTATE"	-- [in] query trigger mode state
"FWVERSION"	-- [in] query firmware version
"DRIVERVERSION"	-- [in] query driver version
"SUPPORT"	-- [in] query driver support info

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"DATA" can be used for querying ADC raw data:
single channel raw ADC data in integer. (SCAN, "1 second")
raw ADC waveform data for trigger mode. (SCAN, " I/O Intr ")

"FLOATDATA" can be used for querying ADC data in floating voltage:
single channel ADC data in voltage. (SCAN, "1 second")
waveform ADC data in floating voltage for trigger mode. (SCAN, " I/O Intr ")

“ENABLE” and “REENABLE”: When using as continuous mode, setting ENABLE to 1 starts the ADC. Setting it to 0 stops the ADC. In trigger mode, setting ENABLE to 1 allows only 1 trigger, i.e. once the ADC is triggered and finished, it won’t be triggered again unless you do another ENABLE. For continuous triggering, set ENABLE to 1 and also set REENABLE to 1.

Example database records:

```
dbLoadRecords("db/example.db")
```

Query data:

```
record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(PREC, "3")
}

record(ai, "$(P):CHANNEL6:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 6) DATA")
        field(PREC, "3")
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) FLOATDATA")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) DATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}
```

Controls:

```
record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}
```

Status:

```
record(ai,"$(P):FIRMWARE_VERSION:IN") {
        field(DTYP,"asynInt32")
        field(INP,"@asyn($(PORT) 0) FWVERSION")
        field(SCAN, "1 second")
}
```

.....

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8413 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

  ```
  ASYN=$(SUPPORT)/asyn/asyn4-14
  IPAC=$(SUPPORT)/ipac/ipac-2.11
  HY8413ASYN=$(TOP)/..
  ```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

  ```
  EPICSPCI=$(SUPPORT)/devlib2-2.0
  ```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

  ```
  cctvmeen/include
          /lib/linux-x86
  ```

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

  ```
  CCTVMEEN=$(SUPPORT)/cctvmeen
  ```

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8413Asyn.dbd

example_LIBS += Hy8413Asyn
example_LIBS += Ipac
example_LIBS += asyn
```

  If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

  NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

  If Conccurent processor for Linux is used, add

```
example_LIBS += cctvmeen
```

- <TOP>/xxxApp/Db/Makefile

  Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

  If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

  Also make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from <TOP>

- Modify stexample.src in iocBoot/iocexample as per next section and run the start-up script from here.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8413AsynInit(char *portName,
                   int vmeSlotNum,
                   int ipSlotNum,
                   int vectorNum,
                   int mode,
                   int range,
                   int format,
                   int clockRate,
                   int extClock)
```

Where:

(1) portName asyn port name
(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (0 - Find One ?)
(5) mode 0 = normal continuous mode, 1 = trigger and FIFO mode
(6) range 0 = +/-10V, 1 = +/-5V
(7) format 0 = 2's complement, 1 = straight
(8) clockrate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz.
16 = 160kHz
(9) extclock 0 = internal clock, 1 = external clock

Example:

```
Hy8413ipAsynInit("ADC8413", 3, 0, 0x80, 1, 0, 1, 9, 0)
```

This configures the 8413 card with
port name: "ADC8413"
carrierNum = 3
IP slot = 0 (slot 'A')
interrupt vector = 0x80
mode = trigger FIFO mode
range = +/-10V
format = straight
scaning rate = 1kHz

clock source = internal

Start up Script Example

The following example is for an IOC that uses Linux on Hytec IOC9010 blade.

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
< envPaths

cd ${TOP}

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
#$(VXWORKS_ONLY)ld < bin/$(ARCH)/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


# Run the configuration function once for each card in the IOC
# This is the function registered in registrarHy8314ip.c
#  Arguments should be something like:
#  * asyn port (string)
#  * VME slot number
#  * IP slot number
#  * - any other arguments that need to be used for configuration
#      at startup time.
```

```
# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1,IPCLCKB=32")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2")

#int Hy8413AsynInit(
#  char *portName,  /* "ADC8413" */
#  int carrierNum,          /* 0 */
#  int ipSlotNum,   /* 0 */
#  int vectorNum,   /* 88 */
#  int mode,        /* 0 (continuous) */
#  int range,       /* 0 (+/-10V) */
#  int format,      /* 1 (straight binary) */
#  int clockRate,   /* 9 (1kHz) */
#  int extClock)    /* 0 (internal) */
Hy8413AsynInit("ADC8413", 0, 0, 88, 1, 0, 1, 9, 0)

dbLoadRecords("db/example.db","P=CARD1,PORT=ADC8413")

# set trace output level for asyn port "ADC8413"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                  0x01: error,
#                  0x11: errors, warnings and debug
#                  0x00: silent
asynSetTraceMask( "ADC8413", 0, 0x00 )
# all driver level messages

iocInit()
```

14. Hy8414 16 Channel 16bit ADC EPICS Asyn Device Driver (Automatic Calibration)

General Information

8414 ADC is similar to 8401. It differentiates from 8401 in the following aspects:

- It has 16 channels 16bit simultaneous ADC.
- It has software selectable range setting either +/-5V or +/-10V.
- It has software selectable gain setting of 1x, 2x, 4x, 8x.
- It has firmware calibrated. This means the calibration is much faster than the software way.

8414 asyn driver provides three modes: continuous mode, trigger mode and gated mode.

Continuous Mode

In continuous mode, the ADC starts acquisition immediately after the IOC is initialised, i.e. it is enabled automatically at the beginning by setting the ENABLE record to 1 in the driver. User can stop this by setting ENABLE record to 0 at any time. Two important configuration arguments in the Init routine are: "average" and "samples".

"average" is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes "average" number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1.

"samples" is used for waveform records which specifies the maximum samples possible to be returned to the records. The real number returned is specified by the NORD field at run time.

Returned data can be either integer or floating. Integer data is the raw ADC values and floating data is converted to voltage values (either +/-10V or +/-5V).

Continuous mode can be stop/start by the ENABLE command at any time.

Trigger Mode

In trigger mode, the ADC doesn't start until it is enabled by the ENABLE record command plus either a software trigger or a hardware trigger. And once triggered, the ADC only collects "samples" + "offset" number of samples then stops.

"offset" is the number of samples at the beginning of trigger that it is less interest to the user so that they can be ignored for the data records calculation or collection. This asynDriver doesn't support negative "offset" for trigger mode.

"samples" defines the number of interest points the ADC should acquire after a trigger and the offset.

"average" is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes "average" number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. There are two flags: overflow and averageOverflow that reflect some abnormities. When the following conditions occur, the flags are set.

- First of all, "offset" + "samples" cannot exceed 64K.
- Whenever the setting of either the "samples" or the "offset" is set, a check is carried out. If "samples" + "offset" exceeds 64k, (64k – "offset") is used for "samples" and overflow flag is set.
- "average" cannot exceed "samples" + "offset". If it does, averageOverflow flag is set and "average" is set to "samples" + "offset".
- "offset" can also be negative (i.e. pre-trigger sampling).

For polled ai records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- Whenever N is less than "offset", averageOverflow flag is set. Also if N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings will be used.
- When N is greater than "offset" and (N - "offset") is greater than or equals to "average", the most recent "average" number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from "offset" to N is used for averaging and the averageOverflow flag is set.

For polled waveform records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- If N is less than or equals to "offset", all data collected as far is returned. NORD is set to N.
- If N is greater than "offset", N – "offset" number of readings is returned and NORD is set to N – "offset".

For callback ai records:

- When "average" exceeds "samples", "samples" number of data acquired is used for averaging. The averageOverflow flag is set.

Data returned can be either integer or floating. Integer data gives the raw ADC value and floating data gives converted voltage value (+/-10V or +/-5V).

Gated Mode

In gated mode, the ADC doesn't acquire data until the ADC is enabled and the hardware inhibit line is de-asserted. And the ADC will be stopped when the hardware inhibit line is asserted or the ADC is disabled. In this mode, the hardware inhibit line functions as a gate to control the ADC.

"samples" setting has no meaning in gated mode.

"average" is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes "average" number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. The overflow and averageOverflow reflect abnormities of the following conditions.

- For gated mode, the ADC starts acquisition after it is initialised to registers but it doesn't store data to memory hence it doesn't serve any gated mode EPICS records until the gate is lifted. At start, the user needs to make sure that the hardware inhibit line is asserted (high). It would otherwise populate the EPICS records once it is enabled.
- "offset" must be less than 64K.
- "average" shouldn't exceed 64k.

For both polled and callback ai records, assuming at a certain point after the gate opens the ADC has collected "N" number of readings.

In the case of a positive "offset"

- If N is less than "offset", averageOverflow flag is set. Also if N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings is used.
- If N is greater than "offset" and (N - "offset") is greater than or equals to "average", the most recent "average" number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from "offset" to N is used for averaging and the averageOverflow flag is set.

In the case of a negative "offset"

- If N is greater than absolute "offset" value, if "average" is also greater than absolute "offset" value, most recent "offset" readings will be used for averaging and the averageOverflow flag is set. If "average" is less than absolute "offset" value, most recent "average" number of samples will be used and the averageOverflow flag is cleared.
- If N is less than absolute "offset" value, averageOverflow flag is set. If N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings is used.

For both callback and polled waveform records, assuming at a point or at the end of the gate the ADC has collected "N" number of readings.

In the case of a positive "offset"

- If N is greater than "offset", (N – "offset") samples are returned starting from "offset".
- Otherwise all data collected is returned.

In the case of a negative “offset”

- If N is greater than absolute “offset” value, “offset” number of samples are returned starting from N + “offset” (note here “offset” is negative).
- Otherwise all data collected is returned.

“offset” is the number of samples at the beginning of gate that it is less interest to the user so that they can be ignored for the data records calculation or collection. If not needed, “offset” can be set to 0. If “offset” is positive number, the collecting point starts from the “offset” and till the end of the gated period. If “offset” is negative, the collection starts from the gated end point and take “offset” number of data backwards.

To enable any mode to work, a “ENABLE” command must be issued first.

For trigger and gated mode, “ENABLE” command means the ADC is ready and wait either for trigger or gate lifting. Once it is triggered or a gate is lifted, the ADC saves the samples to the memory until the number of samples reaches the settings (in trigger mode) or the gate is closed (in gated mode). It then stops and clears the ENABLE setting. To be able to start it again by the following trigger, the user needs to set ENABLE to 1 again. This ensures one trigger or one gate only scenario. To be able to trigger the ADC continuously by a sequence of triggers or gates, set REENABLE record to 1 after setting ENABLE record to 1.

The mode, samples, average, offset, clock rate, using external clock, range setting etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current memory pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers, drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers, drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.

drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU

- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- EPICS core R3.14.8.2 or later.
- RTEMS R4.9.4 or later.

Build the module library

To build the module library,

- Before building the 8414 module, the asyn driver and the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Hy8414ipAsyn.dbd which is located in the src of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query data for FastSweep records
"GENDATA"	-- [in] query normal data
"SCAN_PERIOD"	-- [in] query scanning period in second
"SETAVERAGE"	-- [out] set average online
"SETSAMPLE"	-- [out] set samples online

```
"SETMODE"           -- [out] set mode online
"SETOFFSET"         -- [out] set offset online
"ENABLE"            -- [out] set/clear enable
"SOFTTRIGGER"       -- [out] software trigger
"REENABLE"          -- [out] set/clear reenable
"CLEARBUFFER"       -- not implemented
"SETCLOCKRATE"      -- [out] set clock rate online
"SETEXTCLOCK"       -- [out] set internal/external clock online

"AVERAGEOVERFLOW"   -- [in]query average overflow state
"OVERFLOW"          -- [in]query overflow state
"BUFFERCOUNT"       -- not implemented
"GATETRIGGERSTATE"  -- [in]query trigger/gated mode state
"SUPPORT"           -- [in]query driver support info
```

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"GENDATA" can be used for querying normal ADC data of types:
- raw ADC data in integer
- converted voltage ADC data in floating
- waveform ADC data array in raw integer
- waveform ADC data array in floating voltage

the "field(SCAN, xxx)" can be either " x second" or "I/O Intr".

Example database records:

```
dbLoadRecords("db/example.db")

record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNEL1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
```

```
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) GENDATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}
```

.....

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8414 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
```

```
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8414IP=$(TOP)/..
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the "include" sub-directory, it is the include header file: vme_api_en.h
In the "lib/linux-x86" sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8414ipAsyn.dbd

example_LIBS += Hy8414ipAsyn
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

- Build the application from <TOP>

- Modify stexample.src in iocBoot/iocexample as per next section and run the start-up script from here.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8414ipAsynInit(char *portName,
        int vmeSlotNum,
        int ipSlotNum,
         int vectorNum,
        int samples,
        int average,
        int offset,
        int mode,
        int clockRate,
        int extClock,
        int fastADC)
```

Where:

(1) portName asyn port name
(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (0 - Find One ?)
(5) samples number of samples (not applicable in gated modes)
(6) average number of readings to SUM for average
(7) offset Trigger mode: Offset from trigger point to first ADC reading to return
Gated mode: Offset from the start (or end if negative) of the gated period to the ADC readings to return
Continuous: Not applicable
(8) mode 0 = continuous, 1 = trigger, 3 = gated mode

(9) clockRate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz.
(10) extClock 0 = internal, 1 = extrenal
(11) fastADC flag to say if the ADC is running at fast speed for normal use.
=1 fast, =0 slow for MCA & EPID records

int Hy8414ipAsynConfig(const char *portName,
int gain,
int range);

Where:
(1) portName asyn port name
(2) gain ADC gain setting 0 = 1x, 1 = 2x, 2 = 4x, 3 = 8x
(3) range ADC input range 0= +/- 10V, 1 = +/- 5V

Example:

```
Hy8414ipAsynInit("Hy8414", 3, 0, 10000, 100, 0, 1, 15, 0, 1)
Hy8414ipAsynConfig("Hy8414", 0, 0)
```

This configures the 8414 card with
port name: "Hy8414"
carrierNum = 3
IP slot = 'A'
samples = 10000
average = 100
offset = 0
mode = trigger
scanning rate = 100kHz
clock source = internal
fastADC = yes

gain = 1x
range = +/-10V

Start up Script Example

The following example is for an IOC that uses VxWorks5.5, MVME5500 processor board.

```
#!$(INSTALL)/bin/vxWorks-ppc604_long/example
```

```
cd "/dls_sw/work/R3.14.8.2/support/Hy8414ip-asyn/2-2/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


############################################################
#                 Carrier Card Configuration
############################################################
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel")
# ARGS                        8002/8003/8004
#   ID -- VME slot                  2~21
#   INTLevel -- INT level.          0~7
#==========================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                        IOC9010      PCIe6335    uTCA
#   ID -- carrier ID           99         carrier ID  carrier ID
#   INTLevel -- INT level.     0~7    0~7         0~7 (not used, don't care)
#==========================================================

IPAC3 = ipacAddHy8002("3,2")

#int Hy8414ipAsynInit(char *portName,     - Hy8414
#  int carrierNo,             - IPAC3
#  int ipSlotNum,             - 1 (B)
#  int vectorNum,             - 10
#  int samples,               - 1000
#  int average,               - 10
#  int offset,                - 0
#  int scanMode,              - 1 (trigger mode)
#  int clockRate,             - 9 (1kHz)
#  int extClock,              - 0 (internal)
#  int fastADC)               - 1 (normal, not for mca & EPID)
```

```
Hy8414ipAsynInit("Hy8414", IPAC3, 0, 10, 1000, 10, 0, 1, 9, 0, 1)

#int Hy8414ipAsynConfig(const char *portName,   - Hy8414
#  int gain,                  - 0 (x1)
#  int range )                - 0 (+/-10V)
Hy8414ipAsynConfig("Hy8414", 0, 0)

# int initFastSweep(char *portName, char *inputName,
#                   int maxSignals, int maxPoints)
# portName   = asyn port name for this port
# inputName  = name of input port
# maxSignals = maximum number of input signals.
# maxPoints  = maximum number of points in a sweep.  The amount of memory
#              allocated will be maxPoints*maxSignals*4 bytes
#$(VXWORKS_ONLY)initFastSweep("8414Sweep1","Hy8414", 16, 10000)


##########
# Hytec 8402 DAC in IP site B of the IP carrier card in slot 10.
#$(VXWORKS_ONLY)Hy8402ipConfigure (302, IPAC3, 2, 11)

#initHy8402ipAsyn("DAC", 302)
##########

## Load record instances
dbLoadRecords("db/example.db","P=CARD1,PORT=Hy8414")
#dbLoadRecords("db/examplemca.db")
#dbLoadRecords("db/exampleepid.db")

# set trace output level for asyn port "Hy8414"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                     0x01: error,
#                     0x11: errors, warnings and debug
#                     0x00: silent
asynSetTraceMask( "Hy8414", 0, 0x00 )
# all driver level messages

iocInit()
```

15. Hy8417 8 Channel 24bit ADC EPICS Asyn Device Driver (Automatic Calibration)

General Information

8417 ADC is similar to 8414. It differentiates from 8417 in the following aspects:

- It has 8 channels 24bit simultaneous ADC.
- It can be software set to 16bit ADC.

8417 asyn driver provides three modes: continuous mode, trigger mode and gated mode.

Continuous Mode

In continuous mode, the ADC starts acquisition immediately after the IOC is initialised, i.e. it is enabled automatically at the beginning by setting the ENABLE record to 1 in the driver. User can stop this by setting ENABLE record to 0 at any time. Two important configuration arguments in the Init routine are: "average" and "samples".

"average" is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes "average" number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1.

"samples" is used for waveform records which specifies the maximum samples possible to be returned to the records. The real number returned is specified by the NORD field at run time.

Returned data can be either integer or floating. Integer data is the raw ADC values and floating data is converted to voltage values (either +/-10V or +/-5V).

Continuous mode can be stop/start by the ENABLE command at any time.

Trigger Mode

In trigger mode, the ADC doesn't start until it is enabled by the ENABLE record command plus either a software trigger or a hardware trigger. And once triggered, the ADC only collects "samples" + "offset" number of samples then stops.

"offset" is the number of samples at the beginning of trigger that it is less interest to the user so that they can be ignored for the data records calculation or collection. This asynDriver doesn't support negative "offset" for trigger mode.

"samples" defines the number of interest points the ADC should acquire after a trigger and the offset.

"average" is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes "average" number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. There are two flags: overflow and averageOverflow that reflect some abnormities. When the following conditions occur, the flags are set.

- First of all, "offset" + "samples" cannot exceed 32K for 24bit mode or 64K for 16bit mode.
- Whenever the setting of either the "samples" or the "offset" is set, a check is carried out. If "samples" + "offset" exceeds 32k/64k, (32k/64k – "offset") is used for "samples" and overflow flag is set.
- "average" cannot exceed "samples" + "offset". If it does, averageOverflow flag is set and "average" is set to "samples" + "offset".
- "offset" can also be negative (i.e. pre-trigger sampling).

For polled ai records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- Whenever N is less than "offset", averageOverflow flag is set. Also if N is less than "average", all data collected as far is used to do the averaging. If N is greater than "average", the most recent "average" number of readings will be used.
- When N is greater than "offset" and (N - "offset") is greater than or equals to "average", the most recent "average" number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from "offset" to N is used for averaging and the averageOverflow flag is set.

For polled waveform records, assuming at a certain point after the trigger fires, the ADC has collected N number of readings,

- If N is less than or equals to "offset", all data collected as far is returned. NORD is set to N.
- If N is greater than "offset", N – "offset" number of readings is returned and NORD is set to N – "offset".

For callback ai records:

- When "average" exceeds "samples", "samples" number of data acquired is used for averaging. The averageOverflow flag is set.

Data returned can be either integer or floating. Integer data gives the raw ADC value and floating data gives converted voltage value (+/-10V or +/-5V).

Gated Mode

In gated mode, the ADC doesn't acquire data until the ADC is enabled and the hardware inhibit line is de-asserted. And the ADC will be stopped when the hardware inhibit line is asserted or the ADC is disabled. In this mode, the hardware inhibit line functions as a gate to control the ADC.

"samples" setting has no meaning in gated mode.

“average” is used for ai records of both periodically scanned (SCAN = x seconds) and callback (I/O Intr) cases. It is the number that the driver uses for averaging. At the time of record processing, the driver takes “average” number of samples from the current point and works backwards to do averaging to gain better noise easing. If it is not needed, the user can set it to 1. The overflow and averageOverflow reflect abnormities of the following conditions.

- For gated mode, the ADC starts acquisition after it is initialised to registers but it doesn’t store data to memory hence it doesn’t serve any gated mode EPICS records until the gate is lifted. At start, the user needs to make sure that the hardware inhibit line is asserted (high). It would otherwise populate the EPICS records once it is enabled.
- “offset” must be less than 32k (24bit mode) or 64k (16bit mode).
- “average” shouldn’t exceed 32k/64k.

For both polled and callback ai records, assuming at a certain point after the gate opens the ADC has collected “N” number of readings.

In the case of a positive “offset”

- If N is less than “offset”, averageOverflow flag is set. Also if N is less than “average”, all data collected as far is used to do the averaging. If N is greater than “average”, the most recent “average” number of readings is used.
- If N is greater than “offset” and (N - “offset”) is greater than or equals to “average”, the most recent “average” number of readings is used for averaging and averageOverflow flag is cleared. If not, the ADC values starting from “offset” to N is used for averaging and the averageOverflow flag is set.

In the case of a negative “offset”

- If N is greater than absolute “offset” value, if “average” is also greater than absolute “offset” value, most recent “offset” readings will be used for averaging and the averageOverflow flag is set. If “average” is less than absolute “offset” value, most recent “average” number of samples will be used and the averageOverflow flag is cleared.
- If N is less than absolute “offset” value, averageOverflow flag is set. If N is less than “average”, all data collected as far is used to do the averaging. If N is greater than “average”, the most recent “average” number of readings is used.

For both callback and polled waveform records, assuming at a point or at the end of the gate the ADC has collected “N” number of readings.

In the case of a positive “offset”

- If N is greater than “offset”, (N – “offset”) samples are returned starting from “offset”.
- Otherwise all data collected is returned.

In the case of a negative “offset”

- If N is greater than absolute “offset” value, “offset” number of samples are returned starting from N + “offset” (note here “offset” is negative).
- Otherwise all data collected is returned.

“offset” is the number of samples at the beginning of gate that it is less interest to the user so that they can be ignored for the data records calculation or collection. If not needed, “offset” can be set to 0. If “offset” is positive number, the collecting point starts from the “offset” and till the end of the gated period. If “offset” is negative, the collection starts from the gated end point and take “offset” number of data backwards.

To enable any mode to work, a “ENABLE” command must be issued first.

For trigger and gated mode, “ENABLE” command means the ADC is ready and wait either for trigger or gate lifting. Once it is triggered or a gate is lifted, the ADC saves the samples to the memory until the number of samples reaches the settings (in trigger mode) or the gate is closed (in gated mode). It then stops and clears the ENABLE setting. To be able to start it again by the following trigger, the user needs to set ENABLE to 1 again. This ensures one trigger or one gate only scenario. To be able to trigger the ADC continuously by a sequence of triggers or gates, set REENABLE record to 1 after setting ENABLE record to 1.

The mode, samples, average, offset, clock rate, using external clock, range setting etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current memory pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

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Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux

drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU

- EPICS core R3.14.8.2 or later.
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8417 module, the asyn driver and the ipac driver have to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At the 8417 <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Note, since 8417 at the moment uses 1M byte memory size on board, the carrier card driver if it is 8002/8003/8004 needs to be configured as 1M byte memory per IP or don't set anything which defaults to 1M. An example is shown below:

ipacAddHy8002("3,2")

which defines an 8002 card in slot 3; interrupt level is 2 and 1M by default per IP.

When using other carriers (IOC9010, 6335, 7002/7003 etc), nothing needs to be done.

Database definition file

Database definition file is: Hy8417ipAsyn.dbd which is located in the src of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query data for FastSweep records
"GENDATA"	-- [in] query normal data
"SCAN_PERIOD"	-- [in] query scanning period in second
"SETAVERAGE"	-- [out] set average online
"SETSAMPLE"	-- [out] set samples online
"SETMODE"	-- [out] set mode online
"SETOFFSET"	-- [out] set offset online
"ENABLE"	-- [out] set/clear enable
"SOFTTRIGGER"	-- [out] software trigger
"REENABLE"	-- [out] set/clear reenable
"CLEARBUFFER"	-- not implemented
"SETCLOCKRATE"	-- [out] set clock rate online
"SETEXTCLOCK"	-- [out] set internal/external clock online
"AVERAGEOVERFLOW"	-- [in]query average overflow state
"OVERFLOW"	-- [in]query overflow state
"BUFFERCOUNT"	-- not implemented
"GATETRIGGERSTATE"	-- [in]query trigger/gated mode state
"SUPPORT"	-- [in]query driver support info

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"GENDATA" can be used for querying normal ADC data of types:
raw ADC data in integer
converted voltage ADC data in floating
waveform ADC data array in raw integer
waveform ADC data array in floating voltage
the "field(SCAN, xxx)" can be either " x second" or "I/O Intr".

“FLAOTGENDATA” can be used only for “I/O Intr” floating records.

“ENABLE” and “REENABLE”: When using as continuous mode, setting ENABLE to 1 starts the ADC. Setting it to 0 stops the ADC. In trigger mode, setting ENABLE to 1 allows only 1 trigger, i.e. once the ADC is triggered and finished, it won’t be triggered again unless you do another ENABLE. For continuous triggering, set ENABLE to 1 and also set REENABLE to 1.

Example database records:

```
dbLoadRecords("db/example.db")

record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
```

```
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNEL1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) GENDATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
}
```

.....

Note: For mca/sweep Intr records, they only return values when the 7th parameter in

Hy8417ipAsynInit function call is set to 0, i.e. mca mode. When using mca mode, the scanning rate shouldn't be too fast (max 10kHz under VxWorks or RTEMS, much lower under Linux <=1kHz). Otherwise it might cause 'ring buffer overflows' warning.

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8417 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8417ASYN=$(TOP)/..
```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

```
cctvmeen/include
        /lib/linux-x86
```

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

```
CCTVMEEN=$(SUPPORT)/cctvmeen
```

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8417Asyn.dbd

example_LIBS += Hy8417Asyn
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also please make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from <TOP>
- Modify stexample.src in iocBoot/iocexample as per next section and run the start-up script from here.
- To test the IOC, there is a edm screen named “waveform0.edl” in the example/exampleApp/opi/edl directory when you un-tar the package. Once the IOC is up and running, use command

```
EPICS/extension/bin/linux-x86/edm –x –m “P=CARD1” waveform0.edl
```

to load the edm screen. This waveform is wired to channel 9 (starting from 0) so if you apply a voltage to this channel on the terminal block, you should see the waveform.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8417ipAsynInit(char *portName,
                     int vmeSlotNum,
                     int ipSlotNum,
                     int vectorNum,
                     int mode)
```

Where:
(1) portName: asyn port name
(2) carrierNum: carrier index number when adding a carrier card by ipacAddHy8002 call
(3) ipSlotNum: IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum: Interrupt Vector (0 - Find One ?)
(8) mode: 0 = continuous, 1 = trigger, 3 = gated mode

```
int Hy8417ipAsynInit(char *portName,
                     int samples,
                     int average,
                     int offset,
                     int clockRate,
                     int extClock,
                     int fastADC,
                     int range,
                     int ChannelBit)
```

Where:
(1) portName:asyn port name
(2) samples: number of samples (not applicable in gated modes)
(3) average: number of readings to SUM for average
(4) offset: Trigger mode: Offset from trigger point to first ADC reading to return
Gated mode: Offset from the start (or end if negative) of the gated period to the ADC readings to return
Continuous: Not applicable
(5) clockRate: 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,

12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz.
(6) extClock: 0 = internal, 1 = extrenal
(7) fastADC: flag to say if the ADC is running at fast speed for normal use.
=1 fast, =0 slow for MCA & EPID records
(8) range: ADC input range 0= +/- 10V, 1 = +/- 5V
(9) ChannelBit: ADC bit number. Can be only either 16 or 24.

Example:

```
Hy8417ipAsynInit("ADC8417", 3, 0, 0x80, 1)
Hy8417ipAsynConfig("ADC8417", 10000, 100, 5, 9, 0, 1, 0, 24)
```

This configures the 8417 card with
port name: "ADC8417"
carrierNum = 3
IP slot = 0 (slot 'A')
interrupt vector = 0x80
mode = trigger

samples = 10000
average = 100
offset = 5
scanning rate = 1kHz
clock source = internal
fastADC = yes
range = +/-10V
24 bits resolution

Start up Script Example

The following example is for an IOC that uses VxWorks5.5, MVME5500 processor board.

```
#!$(INSTALL)/bin/vxWorks-ppc604_long/example
cd "/dls_sw/work/R3.14.8.2/support/Hy8417ip-asyn/2-4/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
```

```
# specific things. Alternatively, you can include an architecture
# specific file.
ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


############################################################
#                  Carrier Card Configuration
############################################################
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel")
# ARGS                        8002/8003/8004
#   ID -- VME slot            2~21
#   INTLevel -- INT level.    0~7
#===========================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                        IOC9010       PCIe6335    uTCA
#   ID -- carrier ID           99         carrier ID  carrier ID
#   INTLevel -- INT level.     0~7           0~7   0~7(not used, don't care)
#===========================================================

IPAC3 = ipacAddHy8002("3,2")

#int Hy8417AsynInit(char *portName,  "ADC8417"
#  int carrierNum,      0
#  int ipSlotNum,   0
#  int vectorNum,   88
#  int mode)        0 (continuous)
Hy8417AsynInit("ADC8417", 0, 0, 88, 0)

#int Hy8417AsynExtInit(char *portName,  "ADC8417"
#  int samples,     10000
#  int average,     1000
#  int offset,      0
#  int clockRate,   9 (1kHz)
#  int extClock,    0 (internal)
#  int fastADC,     1 (fast ADC, set to 0 for mca & EPID support)
#  int range,       0 (+/-10V)
#  int ChannelBit)  24
Hy8417AsynExtInit("ADC8417", 10000, 1000, 0, 9, 0, 1, 0, 24)

# int initFastSweep(char *portName, char *inputName,
#                   int maxSignals, int maxPoints)
```

```
# portName   = asyn port name for this port
# inputName  = name of input port
# maxSignals = maximum number of input signals.
# maxPoints  = maximum number of points in a sweep.  The amount of memory
#              allocated will be maxPoints*maxSignals*4 bytes
#$(VXWORKS_ONLY)initFastSweep("8417Sweep1"," ADC8417", 16, 10000)


##########
# Hytec 8402 DAC in IP site B of the IP carrier card in slot 10.
#$(VXWORKS_ONLY)Hy8402ipConfigure (302, IPAC3, 2, 11)

#initHy8402ipAsyn("DAC", 302)
##########

## Load record instances
dbLoadRecords("db/example.db","P=CARD1,PORT= ADC8417")
#dbLoadRecords("db/examplemca.db")
#dbLoadRecords("db/exampleepid.db")

# set trace output level for asyn port " ADC8417"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                     0x01: error,
#                     0x11: errors, warnings and debug
#                     0x00: silent
asynSetTraceMask( " ADC8417", 0, 0x00 )
# all driver level messages

iocInit()
```

16. Hy8402 16 Channel 16bit DAC EPICS Device Driver

General Information

This 8402 EPICS asyn driver provides two modes for updating the outputs: register and trigger mode.

1) Register mode updates the specified I/O channel output when the channel register is loaded.

There are two ways to load the register or memory. By using asynInt32 'ao' record to load the raw value (range 0 ~ 65535) or using asynFloat64 'ao' record to load the voltage value.

Examples:

```
caput CARD4:CHANNEL0:OUT 32768 -- to output the channel0 to 5V (for 0~10V range)
caput CARD4:CHANNELFLOAT12:OUT -5.6 -- to output channel12 to -5.6V (for +/-10V range)
```

2) Trigger mode utilises the on board memory (up to 64K updates per channel) to update the output once triggered by the stored values in the memory as per the clock rate either set internally or by the external clock.

User can use waveform record to download the updating data for example:

```
caput -a CARD4:WAVEFORM0:OUT 7 6553 13106 19659 26212 32765 39318 45871    -- raw data
caput -a CARD4:WAVEFORMFLOAT5:OUT 7 0 1 2 3 4 5 6      -- in voltages
```

These set 7 updates into the memory.

The outputs can be executed just once (if the 'continuous' argument in initialisation routine is set to 0) or continuously wrapped back like a waveform generator if 'continuous' is set to 1.

3) The majority features can be set by initialisation shell command discussed later. Also they can be altered at run time. This includes changing 'mode', 'clock rate' and 'external clock', 'continuous update', etc by the following command records:

```
caput CARD4:MODE:OUT                -- 0:register mode, 1:trigger mode
caput CARD4:CLOCKRATE:OUT           -- please refer to initialisation shell command discussed later
caput CARD4:EXTCLOCK:OUT            -- 0:use internal clock, 1:use external clock
caput CARD4:CONTINUOUSUPDATE:OUT    -- 0:update once from memory, 1:continuous update
.....
```

4) There is a software trigger command to programmable trigger memory update:

caput CARD4:SOFTTRIGGER:OUT 1 -- software trigger

5) 8402 has two range types, +-10V and 0~10V. This is set by the manufacturer so it cannot be selected by software. User can find out this by the following record:

caget CARD4:RANGE:IN -- returning 0x0005 means +/-10V and returning 0x8005 means 0~10V

6) Few status monitoring is also available via records. These include:

caget CARD4:TRGSTATE:IN -- to monitor trigger status, 0:waiting for trigger, 1:updating, 2:finished.
Note: when using external trigger it might not be right
caget CARD4:SUPPORT:IN -- this always returns 3. It means the driver support both register and trigger mode
caget CARD4:FIRMWARE_VERSION:IN -- this returns the IP card firmware version. 301 means version 3.1
caget CARD4:DRIVER_VERSION:IN -- this returns the driver version. 204 means version 2.4

7) User can use 'inhibit' argument in the initialisation routine or the INHIBIT record to set up a hardware enable/disable of memory updates. This only works for trigger mode. The hardware control is wired via the strobe line. When this line is set would stop the DAC memory updating. Only when this line is de-asserted (0), memory updating is allowed.

8) User can use asynReport commands in the EPICS prompt to view the settings and status:

asynReport 1 -- to view the settings and status
asynReport 2 -- to view the calibration factors and current register values.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

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Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

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The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8402 module, the asyn driver and the ipac driver have to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At the 8417 <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Note, since 8402 uses 1M byte memory size on board, the carrier card driver if it is 8002/8003/8004 needs to be configured as 1M byte memory per IP. An example is shown below:

ipacAddHy8002("3,2")

which defines an 8002 card in slot 3; interrupt level is 2 and 1M per IP (default setting).

When using other carriers (IOC9010, 6335, 7002/7003 etc), nothing needs to be done.

Database definition file

Database definition file is: Hy8402Asyn.dbd which is located in the src of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [out] set single ao channel data or waveform channel array of data as raw data
"FLOATDATA"	-- [out] set single ao channel data or waveform channel array of data as voltage
"SETMODE"	-- [out] set register update (0) or trigger and memory update(1)
"NOOFUPDATE"	-- [out] set number of update register
"CONTINUOUS"	-- [out] set up continuous trigger update (1) from memory or single trigger (0)
"SOFTTRIGGER"	-- [out] software trigger
"SETCLOCKRATE"	-- [out] set clock rate (0 ~ 14)
"SETEXTCLOCK"	-- [out] set internal (0)/external(1) clock
"INHIBIT"	-- [out] set to enable using inhibit strobe line to control the memory update (1)
"ZERODAC"	-- [out] clear all outputs to 0V
"RANGE"	-- [in] Query the DAC range, value = 5 means +/-10V and value = 0x8005 (32773 dec) means 0~10V
"COUNTER"	-- [in] query the updating pointer in memory and trigger mode
"TRIGGERSTATE"	-- [in] query trigger mode state
"FWVERSION"	-- [in] query IP card firmware version
"DRIVERVERSION"	-- [in] query driver software version
"SUPPORT"	-- [in] query driver support info

These function code can be used for querying, controlling and monitoring the DAC data, status etc.

Note:

"DATA" command can be used by single ao record or waveform output record when data format is integer

"FLOATDATA" command is similar to "DATA" command apart from the data is in voltage rather than integer raw data. The data is capped if the value is out of the range.

Example database records:

```
dbLoadRecords("db/example.db")
```

Output data:

```
record(ao, "$(P):CHANNEL0:OUT") {
        field(DTYP, "asynInt32")
```

```
		field(OUT, "@asyn($(PORT) 0) DATA")
		field(DESC, "DAC8402 Ch 0")
		field(PREC, "3")
	}

	record(ao, "$(P):CHANNELFLOAT2:OUT") {
		field(DTYP, "asynFloat64")
		field(OUT, "@asyn($(PORT) 2) FLOATDATA")
		field(EGUF, "10.0")
		field(EGUL, "-10.0")
		field(PREC, "3")
	}

	record(waveform,"$(P):WAVEFORM0:OUT") {
		field(SCAN,"Passive")
		field(DTYP,"asynInt32ArrayOut")
		field(INP,"@asyn($(PORT) 0) DATA")
		field(NELM,"7")
		field(FTVL,"LONG")
	}

	record(waveform,"$(P):WAVEFORMFLOAT1:OUT") {
		field(SCAN,"Passive")
		field(DTYP,"asynFloat64ArrayOut")
		field(INP,"@asyn($(PORT) 1) FLOATDATA")
		field(NELM,"7")
		field(FTVL,"DOUBLE")
	}


####### online setting change ##############
	record(longout, "$(P):MODE:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) SETMODE")
	}

	record(longout, "$(P):SOFTTRIGGER:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
	}

	record(longout, "$(P):CONTINUOUSUPDATE:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) CONTINUOUS")
	}
```

```
	record(longout, "$(P):NUMBEROFUPDATE:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) NOOFUPDATE")
	}

####### status ##############

	record(longin, "$(P):RANGE:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) RANGE")
	}

	record(longin, "$(P):UPDATEPOINTER:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) COUNTER")
	}

	record(mbbi, "$(P):FWVERSION:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) FWVERSION")
	}

	record(mbbi, "$(P):DRIVERVERSION:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) DRIVERVERSION")
	}

	record(longin, "$(P):SUPPORT:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) SUPPORT")
	}
	......
```

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8402 asyn driver, use EPICS makeBaseApp.pl script to create

the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8402ASYN=$(TOP)/..
```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

```
cctvmeen/include
        /lib/linux-x86
```

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

```
CCTVMEEN=$(SUPPORT)/cctvmeen
```

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8402Asyn.dbd

example_LIBS += Hy8402Asyn
example_LIBS += Ipac
example_LIBS += asyn
```

  If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
```

```
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also please make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from <TOP>
- Modify stexample.src in iocBoot/iocexample as per next section and run the start-up script from here.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8402ipAsynInit(char *portName,
                     int vmeSlotNum,
                     int ipSlotNum,
                     int vectorNum,
                     int mode,
                     int clockRate,
                     int extClock,
                     int continuous,
                     int inhibit)
```

Where:

(1) portName asyn port name

(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 or alike call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (1 - 255)
(5) mode 0 = register, 1 = trigger
(6) clockRate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz
(7) extClock 0 = internal clock, 1 = external clock
(8) continuous 0 = update from memory once, 1: continuous update from memory. Trigger mode only
(9) inhibit = 0: do not use inhibit strobe, 1: use inhibit strobe to stop updating from memory

Example:

```
Hy8402ipAsynInit("DAC8402", 0, 3, 0x80, 1, 9, 0, 1, 0)
```

This configures the 8402 to
port name: "DAC8402"
carrierNum = 0
IP slot = 3 (slot 'D')
interrupt vector = 0x80
mode = trigger
clock rate = 1KHz
use internal clock
continuous updating once triggerred
do not use inhibit

Start up Script Example

The following example is for an IOC running on Hytec IOC9010 Linux machine.

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
< envPaths

cd ${TOP}

#!$(INSTALL)/bin/vxWorks-ppc604_long/example
#cd "/dls_sw/work/R3.14.8.2/support/Hy8402ip-asyn/2-2/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
```

```
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
#ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


################################################################
#                          Carrier Card Configuration
################################################################
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel,IPMEM=2")
# ARGS                                                  8002/8003/8004
#   ID -- VME slot                  2~21
#   INTLevel -- INT level.      0~7
#=============================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                  IOC9010           PCIe6335    uTCA
#   ID -- carrier ID          99     carrier ID  carrier ID
#   INTLevel -- INT level.     0~7    0~7        0~7(not used, don't care)
#=============================================================

# For PCI/Linux IOC, use
# Note: 8402 doesn't support 32MHz so never set up IPCLOCK=32!
ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2, IPMEM=2")

#int Hy8402AsynInit(
#  char *portName, /* "DAC8402" */
#  int carrierNum,   /* 0 */
#  int ipSlotNum,    /* 0 ~ 5 for IP slot 'A' to 'F' */
#  int vectorNum,    /* 88 */
#  int mode,         /* 0:register update, 1:memory update */
#  int clockRate,    /* 0~14 for 0Hz ~20kHz */
#  int extClock,     /* 0:internal, 1:external */
#  int continuous    /* 0: output from memory once. 1: continuous wrap back. Trigger mode only */
#  int inhibit)      /* 0: do not use inhibit. 1: Use inhibit strobe to stop memory updating. Trigger mode only */
```

```
Hy8402AsynInit("DAC8402", 0, 3, 88, 1, 0, 0, 1, 0)

dbLoadRecords("db/example.db","P=CARD4,PORT=DAC8402")

# set trace output level for asyn port "DAC8402"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                 0x01: error,
#                 0x11: errors, warnings and debug
#                 0x00: silent
asynSetTraceMask( "DAC8402", 0, 0x00 )
# all driver level messages

iocInit()
```

17. Hy8415 16 Channel 18bit DAC EPICS Device Driver (Automatic Calibration)

General Information

8415 DAC is similar to 8402. It differentiates from 8402 in the following aspects:

- It has 16 channels 18bit simultaneous DAC.
- It has programmable 4 different ranges: 0~5V, 0~10V, +/-5V or +/-10V.
- The DAC download data can be either 2's complement or straight.
- It can be programmed to be 16bit DAC.
- It has multip-trigger mode

8415 asyn driver provides three modes: continuous mode, trigger mode and gated mode.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.

- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8415 module, the asyn driver and the ipac driver have to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At the 8415 <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Note, since 8415 uses 1M Byte, the carrier card driver if it is 8002/8003/8004 needs to be configured as 1M byte memory per IP. An example is shown below:

ipacAddHy8002("3,2")

which defines an 8002 card in slot 3; interrupt level is 2 and 1M byte by default memory size per IP.

When using other carriers (IOC9010, 6335, 7002/7003 etc), don't have set anything.

Database definition file

Database definition file is: Hy8415Asyn.dbd which is located in the src folder of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [out] set single ao channel data or waveform channel array of data as raw data
"FLOATDATA"	-- [out] set single ao channel data or waveform channel array of data as voltage
"SETMODE"	-- [out] set register update(0) or trigger and memory update(1)
"NOOFUPDATE"	-- [out] set number of update register
"CONTINUOUS"	-- [out] set up continuous trigger update(1) from memory or single trigger(0)
"SOFTTRIGGER"	-- [out] software trigger
"SETCLOCKRATE"	-- [out] set clock rate(0 ~ 14)
"SETEXTCLOCK"	-- [out] set internal(0)/external(1) clock
"RANGE"	-- [out] software trigger
"FORMAT"	-- [out] set data format to straight(0) or 2's complement(1)
"MULTITGR"	-- [out] set multi pattern memory update trigger mode(1) or normal DAC(0)
"REPEATPATTERN"	-- [out] similar to single trigger mode when setting CONTINUOUS to 0
"SET16BIT"	-- [out] set 16bit DAC(1) or 18bit DAC(0)
"ZERODAC"	-- [out] clear all outputs to 0V
"COUNTER"	-- [in] query the updating pointer in memory and trigger mode
"TRIGGERSTATE"	-- [in] query trigger mode state
"FWVERSION"	-- [in] query IP card firmware version
"DRIVERVERSION"	-- [in] query driver software version
"SUPPORT"	-- [in] query driver support info

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

- "DATA" command can be used by single ao record or waveform output record when data format is integer whether it is straight or 2's complement. If the data is in 2's complement format, please use

- "FORMAT" command to set up the DAC (value = 1)

- "FLOATDATA" command is similar to "DATA" command apart from the data is in voltage rather than integer raw data. The data is capped if it is out of range as per the range setting.

- "MULTITRG" command allows the user to generate different functions (output patterns) by a sequence of triggers. The first trigger triggers the first pattern saved in the memory. The second one triggers the second pattern and so forth. To use this mode, please follow the steps below:

  a. preparing functions data with equal length for each pattern. e.g. in 18bit DAC mode, there are 32K DWORDs for each channel. We can prepare 32 patterns each has 1K DWORDs.
  b. downloading the data by waveform output record to the memory.
  c. setting "Number of Update" register to 1K, i.e. 1024(decimal) by using "NOOFUPDATE" command.

d. triggering the DAC by either software or hardware triggers. The first one will trigger the first pattern, second one triggers the second pattern and so forth until it reaches the end and then wraps.

Example database records:

```
dbLoadRecords("db/example.db")
```

Output data:

```
record(ao, "$(P):CHANNEL0:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) DATA")
        field(DESC, "DAC8415 Ch 0")
        field(PREC, "3")
}

record(ao, "$(P):CHANNELFLOAT2:OUT") {
        field(DTYP, "asynFloat64")
        field(OUT, "@asyn($(PORT) 2) FLOATDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM0:OUT") {
        field(SCAN,"Passive")
        field(DTYP,"asynInt32ArrayOut")
        field(INP,"@asyn($(PORT) 0) DATA")
        field(NELM,"7")
        field(FTVL,"LONG")
}

record(waveform,"$(P):WAVEFORMFLOAT1:OUT") {
        field(SCAN,"Passive")
        field(DTYP,"asynFloat64ArrayOut")
        field(INP,"@asyn($(PORT) 1) FLOATDATA")
        field(NELM,"7")
        field(FTVL,"DOUBLE")
}


####### online setting change ##############

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
```

```
		field(OUT, "@asyn($(PORT) 0) SETMODE")
	}

	record(longout, "$(P):SOFTTRIGGER:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
	}

	record(longout, "$(P):CONTINUOUSUPDATE:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) CONTINUOUS")
	}

	record(longout, "$(P):NUMBEROFUPDATE:OUT") {
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) NOOFUPDATE")
	}

####### status ##############

	record(longin, "$(P):UPDATEPOINTER:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) COUNTER")
	}

	record(mbbi, "$(P):FWVERSION:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) FWVERSION")
	}

	record(mbbi, "$(P):DRIVERVERSION:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) DRIVERVERSION")
	}

	record(longin, "$(P):SUPPORT:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) SUPPORT")
	}

.....
```

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8415 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8415ASYN=$(TOP)/..
```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

```
cctvmeen/include
        /lib/linux-x86
```

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

```
CCTVMEEN=$(SUPPORT)/cctvmeen
```

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8415Asyn.dbd

example_LIBS += Hy8415Asyn
example_LIBS += Ipac
```

```
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += example.db
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

Also make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from <TOP>
- Modify stexample.src in iocBoot/iocexample as per next section and run the start-up script from here.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8415ipAsynInit(char *portName,
                     int vmeSlotNum,
                     int ipSlotNum,
                     int vectorNum,
```

```
                int mode,
                int range,
                int clockRate,
                int extClock)
```

Where:

(1) portName asyn port name
(2) carrierNum carrier index number when adding a carrier card by ipacAddHy8002 or alike call
(3) ipSlotNum IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F)
(4) vectorNum Interrupt Vector (1 - 255)
(5) mode 0 = register, 1 = trigger
(6) range 0 = +/-10V, 1 = +/-5V, 2 = 0-5V, 3 = 0-10V
(7) clockRate 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz,
4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz,
8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz,
12 = 10khz, 13 = 20Khz, 14 = 50kHz
(8) extClock 0 = internal clock, 1 = external clock

```
int Hy8415AsynExtInit(char *portName,
                int continuous,
                int format,
                int multitrigger,
                int repeatpattern,
                int set16bit)
```

Where:

(1) portName asyn port name
(2) contiuous 0 = only trigger once, 1 = continuously trigger. Only for trigger mode
(3) format 0 = data format is straight, 1 = data format is 2's complement
(4) multitrigger 0 = normal mode
1 = multi trigger mode. In this mode, the user saves a number of data patterns (same length) in the memory. When a sequence of triggers come, the first trigger outputs the first pattern, the second outputs the second pattern and so forth until it reaches full than it wraps over again.
(5) repeatpattern 0 = no repeat. 1 = repeat
(6) set16bit 0 = set the DAC to 18bit, 1 = set the DAC to 16bit

Example:

```
Hy8415ipAsynInit("Hy8415", 3, 0, 0x80, 1, 0 , 9, 0)
Hy8415AsynExtInit("Hy8415", 1, 0, 0, 0, 0)
```

This configures the 8415 to
port name: "Hy8415"
carrierNum = 3
IP slot = 0 (slot 'A')

interrupt vector = 0x80
mode = trigger
range = +/-10V
clock rate = 1KHz
use internal clock

continuous triggerring
data format is straight
not multi trigger mode
no repeat
DAC data bit is 18bit

Start-up Script Example

The following example is for an IOC running on Hytec IOC9010 Linux machine.

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
< envPaths

cd ${TOP}

#!$(INSTALL)/bin/vxWorks-ppc604_long/example
#cd "/dls_sw/work/R3.14.8.2/support/Hy8415ip-asyn/1-0/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include architecture
# specific file.
#ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


################################################################
#                        Carrier Card Configuration
################################################################
```

```
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel,IPMEM=2")
# ARGS                                                  8002/8003/8004
#   ID -- VME slot                  2~21
#   INTLevel -- INT level.      0~7
#=========================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                  IOC9010           PCIe6335    uTCA
#   ID -- carrier ID          99     carrier ID  carrier ID
#   INTLevel -- INT level.     0~7    0~7         0~7(not used, don't care)
#=========================================================

# For PCI/Linux IOC, use
ipacAddHyLinux9010("99,1,IPCLCKB=32")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
#IPAC3 = ipacAddHy8002("3,2,IPMEM=2")

#int Hy8415AsynInit(
#  char *portName,        /* "DAC8415" */
#  int carrierNum,        /* 0 */
#  int ipSlotNum,         /* 3 */
#  int vectorNum,         /* 88 */
#  int mode,              /* 0 (register) */
#  int range,             /* 0 (+/-10V) */
#  int clockRate,         /* 9 (1kHz) */
#  int extClock)          /* 0 (internal) */
Hy8415AsynInit("DAC8415", 0, 3, 88, 1, 0, 0, 0)

# extension Init
#Hy8415AsynExtInit(
#  char *portName,        /* "DAC8415" */
#  int continuous,        /* 1 (yes continuous. NOTE, this is needed only in trigger mode) */
#  int format,            /* 0 (straight) */
#  int multitrigger,      /* 0 (no multi triggers ) */
#  int repeatpattern,     /* 0 (no repeat when in multi trigger mode) */
#  int set16bit)          /* 0 (18bit mode) */
Hy8415AsynExtInit("DAC8415", 1, 0, 0, 0, 0)

dbLoadRecords("db/example.db","P=CARD4,PORT=DAC8415")

# set trace output level for asyn port "DAC8415"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                  0x01: error,
```

```
#               0x11: errors, warnings and debug
#               0x00: silent
asynSetTraceMask( "DAC8415", 0, 0x00 )
# all driver level messages

iocInit()
```

18. Hy8601 EPICS "Model 3"Asyn Device Driver

Download the Software

Hytec 8601 step motor asyn driver will be included in the EPICS motor module in the next release (maybe motorR6-5-2 or motorR6-6) which can be downloaded from EPICS website:
http://www.aps.anl.gov/bcda/synApps/motor/index.html

If the motor module hasn't included the Hytec 8601 module, it can be downloaded from Hytec website
http://www.hytec-electronics.co.uk/Download.aspx

Note: Hytec 8601 asyn driver is developed as per 'model 3' asyn framework. It needs the latest motor module for support. Please refer to next section.

Support Modules

- asyn driver version asyn4-13-1 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- devlib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- motor module version later than motorR6-5-1. Currently the 'model 3' version can be downloaded from subversion https://subversion.xor.aps.anl.gov/synApps/motor/trunk.
  This will be formally released some stage on the official EPICS website.
- EPICS core R3.14.8.2 or later.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8601 module, the asyn driver and the ipac driver has to be built successfully first.
- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.

- After download the motor module from the subversion, modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- At motor module <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: HytecMotorDriver.dbd which is located in the src of the module.

Testing Database(s)

Two databases are needed to run both motor record and individual controls.

```
dbLoadRecords("db/basic_asyn_motor.db")
dbLoadRecords("db/HytecMotorControl.db", "dev=IP8601,area=TEST,locn=LAB,PORT=Hy8601")
```

Where:

basic_asyn_motor.db is the motor record database. It initialises 4 axes.

HytecMotorControl.db is the special controls for Hy8601 motor controller. It contains few extra asyn records including POWER, BRAKE controls, synchronous read of absolute position and encoder position and firmware version etc as below.

```
record(bo,"$(dev):$(area):$(locn):POWER") {
   field(DTYP,"asynInt32")
   field(OUT,"@asyn($(PORT) 0)HYTEC_POWER")
   field(VAL, "1")
   field(ONAM, "On")
   field(ZNAM, "Off")
}

record(bo,"$(dev):$(area):$(locn):BRAKE") {
   field(DTYP,"asynInt32")
   field(OUT,"@asyn($(PORT) 0)HYTEC_BRAKE")
```

```
    field(VAL, "1")
    field(ZNAM, "Set")
    field(ONAM, "Rls")
}

record(ai,"$(dev):$(area):$(locn):POSN") {
    field(PINI, "YES")
    field(DTYP,"asynInt32")
    field(INP,"@asyn($(PORT) 0)MOTOR_POSITION")
    field(SCAN, "1 second")
}

record(ai,"$(dev):$(area):$(locn):EN_POSN") {
    field(PINI, "YES")
    field(DTYP,"asynInt32")
    field(INP,"@asyn($(PORT) 0)MOTOR_ENCODER_POSITION")
    field(SCAN, "1 second")
}


record(ai,"$(dev):$(area):$(locn):FIRMWARE_VERSION") {
    field(PINI, "YES")
    field(DTYP,"asynInt32")
    field(INP,"@asyn($(PORT) 0)HYTEC_FWVERSION")
    field(SCAN, "1 second")
}
```

There are other records in the HytecMotorControl.db which can return the positions synchronously and return the firmware version etc.

These positions are raw values in terms of the "counts". These records can be read by "ai" records and can be converted to engineering values by EGUF, EGUL etc.

Notes:

- The power control uses AUX1 of the 8601 CSR. As it indicates in the record above, command

```
caput $(dev):$(area):$(locn):POWER 1
```

means power "On" and it sets the AUX1 bit, i.e. AUX1 output high (1).

```
caput $(dev):$(area):$(locn):POWER 0
```

means power "Off" so it clears AUX1 bit, i.e. AUX1 output low (0). Command

- The brake control uses AUX2 of the 8601 CSR. As it indicates in the record above, command

caput $(dev):$(area):$(locn):BRAKE 1

means to release the brake. It clears AUX2 bit, i.e. AUX2 output low (0). Command

caput $(dev):$(area):$(locn):BRAKE 0

means set the brake. It sets the AUX2 bit, i.e. AUX2 output high (1).

- The firmware version record returns the IP card PCB board issue number and the firmware version

caget $(dev):$(area):$(locn):FIRMWARE_VERSION

will return something like '2210' for example, whereas the first 2 is the PCB issue number and 210 is the firmware version.

Building an Example Application

To build an example to test the 8601 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s).

- <TOP>/configure/RELEASE

Change the EPICS_BASE and SUPPORT to the proper directories.
Add ASYN, IPAC and MOTOR modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
MOTOR=<the motor module dir>/motorR6-5-2
```

If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

cctvmeen/include
/lib/linux-x86

In the “include” sub-directory, it is the include header file: vme_api_en.h
In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

To add this module in the RELEASE, add the following line:

CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += motorSupport.dbd
example_DBD += motorRecord.dbd
example_DBD += drvIpac.dbd
example_DBD += HytecMotorDriver.dbd

example_LIBS += HytecMotor
example_LIBS += motor
example_LIBS += Ipac
example_LIBS += asyn
```

If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

Copy HytecMotorControl.db to the Db directory and add the following lines in the Makefile of the Db directory:

```
DB += basic_asyn_motor.db
DB += HytecMotorControl.db
```

- <TOP>/xxxApp/Db

Copy basic_asyn_motor.template and basic_asyn_motor.substitutions files to this folder. The basic_asyn_motor.substitutions file should have similar items like this:

file "asyn_motor.template"

```
{
pattern
{P, N, M, DTYP, PORT, ADDR, DESC, EGU, DIR,  VELO,  VBAS,  ACCL,  BDST,  BVEL,  BACC,  MRES,  PREC,  DHLM,  DLLM,  INIT}
{CARD1,  0,  ":axis$(N)",  "asynMotor",  Hy8601A,  0,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD1,  1,  ":axis$(N)",  "asynMotor",  Hy8601A,  1,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD1,  2,  ":axis$(N)",  "asynMotor",  Hy8601A,  2,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD1,  3,  ":axis$(N)",  "asynMotor",  Hy8601A,  3,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
}
```

If a system has more than once 8601 card, say there is a second card, add the following lines to the file and so forth.

```
{CARD2,  0,  ":axis$(N)",  "asynMotor",  Hy8601B,  0,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD2,  1,  ":axis$(N)",  "asynMotor",  Hy8601B,  1,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD2,  2,  ":axis$(N)",  "asynMotor",  Hy8601B,  2,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
{CARD2,  3,  ":axis$(N)",  "asynMotor",  Hy8601B,  3,    "motor $(N)",  degrees,  Pos,  100,  1,  64,   0,   1,   .2,   0.01,  5,    100,  -100,  ""}
```

- <TOP>/ iocBoot/iocBootexample /Makefile

If the IOC is built for Linux, modify the ARCH variable value to

```
ARCH = linux-x86
```

- Build the application from <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start up script from here.

Example of the configuration shell command for two 8601 cards, say one in slot A and one in slot B, one can use the following:

```
Hytec8601Configure("Hy8601A", 4, 500, 1000, 0, 0, 0, 70, 0, 0.25, 0.25, 0.25, 0.25)
Hytec8601Configure("Hy8601B", 4, 500, 1000, 1, 0, 1, 71, 0, 0.25, 0.25, 0.25, 0.25)
```

- The package comes with a testing exmple testExample. After the tweaks and do a compile of the example, one can try the edm screen in the testExample/Display directory to test the motor records. The edm command is:

<epics extensions/bin/linux-x86/edm –x –m “P=CARD1:,M=axis0” motorx_all_mc.edl

For second card axis 2, try this:

<epics extensions/bin/linux-x86/edm –x –m “P=CARD2:,M=axis2” motorx_all_mc.edl

And so forth.

Configuration Shell Command for Start-up Script

8601 shell command takes the following form:

```
int Hytec8601Configure(char *portName,
                       epicsUInt16 numAxes,
                       epicsUInt16 movingPollPeriod,
                       epicsUInt16 idlePollPeriod,
                       epicsUInt16 cardnum,
                       epicsUInt16 ip_carrier,
                       epicsUInt16 ipslot,
                       epicsUInt16 vector,
                       epicsUInt16 useencoder,
                       epicsDouble encoderRatio0,
                       epicsDouble encoderRatio1,
                       epicsDouble encoderRatio2,
                       epicsDouble encoderRatio3)
```

Where:

(1) portName asyn port name
(2) numAxes number of axes
(3) movingPollPeriod status polling time period when motor is moving in ms
(4) idlePollPeriod status polling time period when motor is stopped in ms
(5) cardnum Arbitrary card number to assign to this controller
(6) ip_carrier which previously configured IP carrier in the IOC
(7) ipslot which IP Slot on carrier card (0=A, 1=B etc.)
(8) vector which Interrupt Vector
(9) useencoder - bit0 for axis0, bit1 for axis1, bit2 for axis2 and bit3 for axis3.
Other bits not used. 1=use encoder, 0=don't use encoder !
(10) encoderRatio0 - axis0 hardware encoder ratio
(11) encoderRatio1 - axis1 hardware encoder ratio
(12) encoderRatio2 - axis2 hardware encoder ratio
(13) encoderRatio3 - axis3 hardware encoder ratio

Please note: since the configuration routine has more than 10 parameters, when loading it in VxWorks start-up script, the OS complains about "too many parameters…" This is because in VxWorks versions up to now, the maximum parameter number can be only 10. To couple this, we can just add

iocsh()

before the Hytec8601configure is called in the start up script.

Example:

```
Hytec8601Configure("Hy8601", 4, 500, 1000, 0, IPAC0, 0, 70, 15, 0.25, 0.25,
0.25, 0.25)
```

This configures the 8601 card with

port name: Hy8601
4 axes
poll status every 500ms when moving
poll status every 1000ms when stopped
card number = 0
carrier serial number = 0
ipslot = site A
interrupt vector = 70
all 4 axes use encoder
all 4 axes have quardrature encoder hence their ratios are 0.25

Start-up Script Example

The following example is for an IOC that uses RTEMS R4.9.4, MVME5500 processor board.

```
# Change directory to TOP of application
cd("../..")
iocBoot=pwd()
ld( "bin/RTEMS-mvme5500/MotionControl.obj")
#ld < bin/vxWorks-ppc604_long/MotionControl.munch     #for VxWorks

## Set common environment variables
#< all/pre_st.cmd
epicsEnvSet("IOC_NAME",  "MC02")
epicsEnvSet("LOCA_NAME", "B025")
epicsEnvSet("ENGINEER", "Condamoor, Shantha")

epicsEnvSet( "EPICS_CA_MAX_ARRAY_BYTES", "30000")

# Register all support components
dbLoadDatabase( "dbd/MotionControl.dbd")
MotionControl_registerRecordDeviceDriver( pdbbase)

bspExtVerbosity=0

############################################################
# Configure Hytec 8002 carriers
#   8002 carrier VME slot: 3
#     INT level: 5
#     Memory per IP: 1MB
#     Memory mapping offset: 8384
# ===================================================================
#The typical output on beatnik looks like this:
# Cexp@till35>BSP_VMEOutboundPortsShow()
# Tsi148 Outbound Ports:
# Port  VME-Addr   Size       PCI-Adrs   Mode:
```

```
# 0:    0x20000000 0x0e000000 0x90000000 A32, SUP, D32, SCT
# 1:    0x00000000 0x00ff0000 0x9f000000 A24, SUP, D32, SCT
# 2:    0x00000000 0x00010000 0x9fff0000 A16, SUP, D32, SCT
# 7:    0x00000000 0x01000000 0x9e000000 CSR, SUP, D32, SCT
# ================================================================
# A32 space configured to start here:  0x20000000
# Tell the carrier not to use geographic addressing
IPAC0=ipacAddHy8002("3,5,IPMEM=1,MEMOFFS=8384")

#
# Hytec MDS-8 8601 driver setup parameters:
# int Hytec8601Configure(char *portName,
#           epicsUInt16 numAxes,
#           epicsUInt16 movingPollPeriod,
#           epicsUInt16 idlePollPeriod,
#           epicsUInt16 cardnum,
#           epicsUInt16 ip_carrier,
#           epicsUInt16 ipslot,
#           epicsUInt16 vector,
#           epicsUInt16 useencoder,
#           epicsDouble encoderRatio0,
#           epicsDouble encoderRatio1,
#           epicsDouble encoderRatio2,
#           epicsDouble encoderRatio3)
#     (1) portName   asyn port name
#     (2) numAxes    number of axes
#     (3) movingPollPeriod  status polling time period when motor is moving in ms
#     (4) idlePollPeriod   status polling time period when motor is stopped in ms
#     (5) cardnum    Arbitrary card number to assign to this controller, not used
#     (6) ip_carrier which previously configured IP carrier in the IOC
#     (7) ipslot     which IP Slot on carrier card (0=A etc.)
#     (8) vector     which Interrupt Vector (0 - Find One ?)
#     (9) useencoder - bit0 for axis0, bit1 for axis1, bit2 for axis2 and bit3
for axis3.
#     Other bits not used. 1=use encoder, 0=don't use encoder !
#     (10) encoderRatio0  - axis0 hardware encoder ratio
#     (11) encoderRatio1  - axis1 hardware encoder ratio
#     (12) encoderRatio2  - axis2 hardware encoder ratio
#     (13) encoderRatio3  - axis3 hardware encoder ratio

Hytec8601Configure("Hy8601", 4, IPAC0, 0, 0, 70, 0, 0.25, 0.25, 0.25, 0.25)


# ========================================================
# New Hytec Motor Databases
# ========================================================
dbLoadRecords("db/basic_asyn_motor.db")
dbLoadRecords("db/HytecMotorControl.db",
dev=IP8601,area=TEST,locn=LAB,PORT=Hy8601")
# ========================================================
iocInit()
```

19. Hy8424 4 Channel 16bit 1MHz ADC EPICS Asyn Device Driver (Automatic Calibration)

General Information

8424 ADC has the scanning rate up to 1MHz per second simultaneously for all 4 channels. From firmware version 1106 and EPICS driver 2.3, it now supports fast averaging by the firmware and EPICS software. It significantly increases the usage of onboard 2MB memory. For continuous, trigger and gated mode, it can store 128k averaged samples per channel, for transient recorder mode, it can store 256k samples (not averaged).

Due to the high acquisition speed, running continuous mode requires fast data transferring capability of the processor from onboard memory to CPU memory. It would otherwise wrap round the circular data buffer. When used as trigger mode or gated mode or as transient recorder mode, data will be stored in onboard memory which can be read out when interrupt is generated.

This version of 8424 ADC asyn driver provides five modes:

- continuous mode
- trigger mode
- gated mode
- simple transient recorder mode
- voltage trigger transient recorder mode

Generic Init Routine

A generic initialisation routine needs to be called before any mode specific init routine. This routine is done by the class constructor:

```
int Hy8424AsynInit(char *portName, int vmeSlotNum, int ipSlotNum, int vectorNum,
                   int clockRate, int extClock, int range)
```

where:

portName	= asyn port name
carrierNum	= carrier index number when adding a carrier card by ipacAddHy8002 call
ipSlotNum	= IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F),
vectorNum	= interrupt vector (has to be none zero),
clockRate	= 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz, 4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz, 8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz, 12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz, 16 = 200khz, 17 = 500Khz, 18 = 1MHz.

extClock = 0 = internal, 1 = extrenal,
range = 0 : +/-10V, 1 : +/-5V

Continuous Mode

In continuous mode, the ADC starts acquisition immediately after the IOC is initialised, i.e. it is enabled automatically at the beginning by the driver. User can stop the ADC by using asyn function code ENABLE (set this record to 0) at any time. Continuous mode init routine:

int Hy8424ContinueMode(char *portName, int samples, int average, int fastADC)

where:
portName = asyn port name, the same name string as the generic init routine
average = number of readings to SUM for average
fastAdc = flag to say if the ADC is running at fast speed for normal use. =1 fast,
=0 slow for MCA & EPID records

"average" is the number of samples at the given speed (scanning rate) that the firmware accumulates and then pushes the sum into 32bit memory location. When driver (record) is processed, the driver calculate the averaging value that is returned to the user. This combination functions like an onboard DSP filter. If averaging is not needed, can set it to 1.

Returned data can be either integer or floating. Integer data is the raw ADC values and floating data is converted to voltage values (either +/-10V or +/-5V).

Trigger Mode

When using as trigger mode, the ADC doesn't start until it is enabled by the ENABLE record command plus, either a software trigger or a hardware trigger. Its init routine:

int Hy8424TriggerMode(char *portName, int samples, int average, double offset,
int fastADC, int triggerEdge)

Where: -
portName = asyn port name
samples = number of samples post trigger
average = number of readings to SUM for average
offset = Offset to start collecting after trigger.
fastAdc = flag to say if the ADC is running at fast speed for normal use. =1 fast,
=0 slow for MCA & EPID records
triggerEdge = 0 : rising edge; 1 : falling edge; 2 : both edge

"ENABLE" command must be issued first before trigger.

Once triggered, the ADC collects "samples" number of averaged samples and then stops.

"offset" is where the interested data should start after the trigger. This asynDriver doesn't support negative "offset" for trigger mode.

"samples" defines the number of interest points the ADC should acquire after the trigger.

"average" has the same meaning as in the continuous mode.

The maximum "average" number is 32768.

There is overflow flags:

- When "samples" exceeds 128K (for continuous, trigger or gated mode) or 256K (for transient recorder mode), overflow is set.
- If the "offset" is greater than "samples", "offset" is forced to be half of "samples" and overflow flag is set.
- "offset" cannot be negative in trigger mode (i.e. pre-trigger sampling).

For waveform records, if the collected samples (averaged) is more than asked (nelements), it will return nelements-offset data. Otherwise, offset is compromised.

Data returned can be either integer or floating. Integer data gives the raw ADC value and floating data gives converted voltage value (+/-10V or +/-5V).

Gated Mode

In gated mode, user can use an external pulse to control the ADC acquisition. The ADC acquires data only when the external gate pulse is asserted. This is implemented via the carrier board front panel inhibit LEMO input line. The ADC doesn't acquire data until the ADC is enabled and the hardware inhibit line is asserted. And the ADC will be stopped when the hardware inhibit line is de-asserted or the ADC is disabled. In this mode, the hardware inhibit line functions as a gate to control the ADC.

The init routine:

int Hy8424GatedMode(char *portName, int average, double offset, int fastADC)

Where: -

portName	= asyn port name
average	= number of readings to SUM for average
offset	= Offset from the start (or end if negative) of the gated period to the ADC readings to return
fastAdc	= flag to say if the ADC is running at fast speed for normal use. =1 fast, =0 slow for MCA & EPID records

"ENABLE" command must be issued first before the gate.

"average" has the same meaning as in the continuous mode.

In this mode, there is also overflow flag.

- For gated mode, the ADC starts acquisition after it is initialised to registers but it doesn't store data in to the memory hence it doesn't serve any gated mode EPICS records until the gate is lifted. At start, the user needs to make sure that the hardware inhibit line is de-asserted (high). It would otherwise populate the EPICS records once it is enabled.
- "offset" must be less than 256K.

For both callback and polled waveform records, in the case of a positive "offset", it collects in a similar way as trigger mode. In the case of a negative "offset", if the collected samples (averaged) is more than nelements+(-offset), it colects nelements+(-offset) number of data. Otherwise offset is compromised.

"offset" is the number of samples that the user is not interested at the start point of collecting in case of positive offset, or the user is interested more data prior to the collecting point.

Simple Transient Recorder Mode

Simple transient recorder once triggered stores acquisition data for the set period of time (number of conversions up to 256k samples). Each channel will record the positions when its signal is above the pre-set lower threshold point and the signal is below the pre-set upper threshold point. It also records the peak value of each channel.

The init routine:

```
int Hy8424SimpleTRMode(char *portName, int samples, double delay, double thresholdlow0,
                       double thresholdhigh0, double thresholdlow1, double thresholdhigh1, double thresholdlow2,
                       double thresholdhigh2, double thresholdlow3, double thresholdhigh3, int outputEdge,
                       int stopInEdge)
```

Where: -

portName	= asyn port name
sample	= number of samples post trigger
delay	= delay time from the trigger to the start point of acquisition
thresholdlow0	= First threshold point for channel 0. In voltage unit
thresholdhigh0	= Second threshold point for channel 0. In voltage unit
thresholdlow1	= First threshold point for channel 1. In voltage unit
thresholdhigh1	= Second threshold point for channel 1. In voltage unit
thresholdlow2	= First threshold point for channel 2. In voltage unit
thresholdhigh2	= Second threshold point for channel 2. In voltage unit
thresholdlow3	= First threshold point for channel 3. In voltage unit
thresholdhigh3	= Second threshold point for channel 3. In voltage unit

outputEdge = Start Out TTL level. 0=high, 1=low
stopInEdge = Stop in TTL level: 0=high, 1=low

“ENABLE” command must be issued first before trigger.

The "delay" setting is the offset for the ADC to start after the trigger. Its unit is second and the smallest step is 10us.

There are two types of waveform records to present the acquired data. The one by using "GENDATA" function code returns all data from start to the end. When using "DATA" function code, the waveform records only return the interested part, i.e. from lower threshold point to the upper threshold point.

Voltage Trigger Transient Recorder Mode

In this mode, either a software trigger or external hardware trigger starts the ADC and stores data in the pre-set circular buffer (up to 64k samples). Once the selected (by init routine) channel's voltage is above the defined lower threshold, the ADC starts post-trigger digitization until either the number of conversion setting is reached (up to 256k - circular buffer size) or memory overflows or stopped by external stop signal or software stop command.

The init routine:

int Hy8424VoltageTRMode(char *portName, int sample, int VTChannel, double thresholdlow,
double thresholdhigh, int buffer, int outputEdge, int stopInEdge)

Where: -
portName = asyn port name
sample = number of samples post trigger
VTChannel = voltage trigger channel. 0~3
thresholdlow = First threshold point for VTChannel . In voltage unit
thresholdhigh = Second threshold point for VTChannel. In voltage unit
buffer = Circular buffer size. 0~65535
outputEdge = Start Out TTL level. 0=high, 1=low
stopInEdge = Stop in TTL level: 0=high, 1=low

The driver presents the digitized data in two waveform records. The one by using "GENDATA" function code will return all data from start to the end including the circular buffer. When using "DATA" function code, the waveform records only return the interested part, i.e. from lower threshold point to upper threshold.

“ENABLE” command must be issued first before trigger.

For trigger, gated mode and transient recorder mode, “ENABLE” command means the ADC is ready and wait either for trigger or gate lifting. Once it is triggered or the gate is lifted, the ADC starts acquiring to the memory until the number of samples reaches the settings (in trigger mode) or the gate is closed (in gated

mode). It then stops and clears the ENABLE setting. To be able to start it again by the following trigger, the user needs to set ENABLE to 1 again. This ensures one trigger or one gate only scenario. To be able to trigger the ADC continuously by a sequence of triggers or gates, set REENABLE record to 1 after setting ENABLE record to 1.

The samples, average, offset, clock rate, using external clock, range setting etc can be changed online by the relative records. Also the user can query trigger mode trigger status, the current memory pointer and firmware/driver version etc. Please refer to the database records.

Download the Software

The software can be downloaded from Hytec website http://www.hytec-electronics.co.uk/Download.aspx .

The hardware user manual can also be downloaded from the same website page above.

Any problems downloading the software, please contact Hytec support at support@hytec-electonics.co.uk .

Support Modules

The following support modules are required when building the driver library. These modules can be downloaded from the official EPICS website http://www.aps.anl.gov/epics/index.php .

- asyn driver version asyn4-12 or later.
- ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
  drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers,
  drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers,
  drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade.
  drvHy8002Concurrent.c for 8002 VME carrier when used with Concurrent processor board in Linux
  drvHyMrfConcurrent.c for Micro Research VME Module when used with Concurrent CPU in Linux
  drvHy8001.c is used for 8001 VME carrier and IO board for VxWorks or RTEMS with Motorola CPU
- EPICS core R3.14.8.2 or later.
- devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.
- RTEMS R4.9.4 or later.

Building the module library

To build the module library,

- Before building the 8424 module, the asyn driver and the ipac driver have to be built successfully first.

- If the IOC is built on IOC9010 blade with RTEMS, devLib2 module has to be built as well.
- Modify EPICS_BASE and SUPPORT environment variables in the configure/RELEASE file to your site
- Make sure the CONFIG_SITE.linux-x86.Common file under EPICS_BASE/configure/os has proper target architecture set, the cross compiler if the build is not for Linux itself.
- If Concurrent VME processor for Linux is used, cctvmeen module and hytec_cct_driver device driver are needed. Please contact Hytec for more information.
- At the 8424 <TOP> folder, do make.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Note, since 8424 uses 2M byte memory size on board, the carrier card driver if it is 8002/8003/8004 needs to be configured as 2M byte memory per IP. An example is shown below:

ipacAddHy8002("3,2, IPMEM=2")

which defines an 8002 card in slot 3; interrupt level is 2 and 2M by default per IP.

When using other carriers (IOC9010, 6335, 7002/7003 etc), nothing needs to be done.

Database definition file

Database definition file is: Hy8424ipAsyn.dbd which is located in the src of the module.

Testing Database(s)

asyn function code:

"DATA"	-- [in] query data for FastSweep records
"GENDATA"	-- [in] query normal data
"SCAN_PERIOD"	-- [in] query scanning period in second
"SETAVERAGE"	-- [out] set average online
"SETSAMPLE"	-- [out] set samples online
"SETMODE"	-- [out] set mode online
"SETOFFSET"	-- [out] set offset online
"ENABLE"	-- [out] set/clear enable
"SOFTTRIGGER"	-- [out] software trigger

"REENABLE"	-- [out] set/clear reenable
"CLEARBUFFER"	-- not implemented
"SETCLOCKRATE"	-- [out] set clock rate online
"SETEXTCLOCK"	-- [out] set internal/external clock online
"RANGE"	-- [out] range setting
"FASTADC"	-- [out] fast ADC or slot ADC for mca and EPID
"TRIGEDGE"	-- [out] trigger edge when using as trigger mode
"TRCHANNEL"	-- [out] defines channel to trigger for voltage trigger transient recorder mode
"BUFFERSIZE"	-- [out] circular buffer size
"TRTHRESHOLDLOW"	-- [out] channel lower threshold
"TRTHRESHOLDHIGH"	-- [out] channel upper threshold
"TRPEAK"	-- [in] channel peak value
"TROUTEDGE"	-- [out] trigger output edge
"TRINEDGE"	-- [out] stop input edge
"SOFTSTOP"	-- [out] software stop command
"AVERAGEOVERFLOW"	-- [in] query average overflow state
"OVERFLOW"	-- [in] query overflow state
"BUFFERCOUNT"	-- not implemented
"GATETRIGGERSTATE"	-- [in] query trigger/gated mode state
"SUPPORT"	-- [in] query driver support info

These function code can be used for querying, controlling and monitoring the ADC data, status etc.

Note:

"GENDATA" can be used for querying normal ADC data of types:
- raw ADC data in integer
- converted voltage ADC data in floating
- waveform ADC data array in raw integer
- waveform ADC data array in floating voltage
- waveform for transient recorder full range

the "field(SCAN, xxx)" can be either " x second" or "I/O Intr".

“ENABLE” and “REENABLE”: When using as continuous mode, ADC starts automatically and this is set to 1.Setting it to 0 stops the ADC. In trigger mode, setting ENABLE to 1 allows only 1 trigger, i.e. once the ADC is triggered and finished, it won’t be triggered again unless you do another ENABLE. For continuous triggering, set ENABLE to 1 and also set REENABLE to 1.

For transient recorder modes, records (including peak values and waveform records) only get data by the number of conversion interrupt, i.e. these record's SCAN fields have to be "I/O Intr".

Example database records:

```
dbLoadRecords("db/8424.db")

record(ai, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNEL1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(ai, "$(P):CHANNELFLOAT0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynFloat64")
        field(INP, "@asyn($(PORT) 0) GENDATA")
        field(EGUF, "10.0")
        field(EGUL, "-10.0")
        field(PREC, "3")
}

record(waveform,"$(P):WAVEFORM0:IN") {
        field(SCAN, "1 second")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) GENDATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}

record(longout, "$(P):MODE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SETMODE")
}

record(longout, "$(P):SOFTTRIGGER:OUT") {
        field(DTYP, "asynInt32")
```

```
        field(OUT, "@asyn($(PORT) 0) SOFTTRIGGER")
    }
```

.....

Note: For mca/sweep Intr records, they only return values when the 7th parameter in Hy8424ipAsynInit function call is set to 0, i.e. mca mode. When using mca mode, the scanning rate shouldn't be too fast (max 10kHz under VxWorks or RTEMS, much lower under Linux <=1kHz). Otherwise it might cause 'ring buffer overflows' warning.

Example database records for transient recorder:

```
###### Waveform value in raw data format #########
    record(waveform,"$(P):WF_FULL0:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP,"asynInt32ArrayIn")
        field(INP,"@asyn($(PORT) 0) GENDATA")
        field(NELM,"3000")
        field(FTVL,"LONG")
    }

###### Waveform populated after interrupt in voltage #################
    record(waveform,"$(P):INTR_WF_INTEREST_FLOAT1:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP,"asynFloat64ArrayIn")
        field(INP,"@asyn($(PORT) 1) FLOATGENDATA")
        field(NELM,"2000")
        field(FTVL,"DOUBLE")
    }

####### Transit recorder peak raw data #############
    record(ai, "$(P):CHANNELPEAK1:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 1) TRPEAK")
        field(PREC, "3")
    }

###### Threshold points ############################
    record(ao, "$(P):LOWER_THRESHOLD0:OUT") {
        field(DTYP, "asynFloat64")
        field(OUT, "@asyn($(PORT) 0) TRTHRESHOLDLOW")
        field(PREC, "3")
    }

    record(ao, "$(P):UPPER_THRESHOLD0:OUT") {
```

```
		field(DTYP, "asynFloat64")
		field(OUT, "@asyn($(PORT) 0) TRTHRESHOLDHIGH")
		field(PREC, "3")
	}

###### Threshold positions ############################
	record(longin, "$(P):LOWER_POINTER0:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) TRTHRESHOLDLOW")
	}

	record(longin, "$(P):UPPER_POINTER0:IN") {
		field(SCAN, "1 second")
		field(DTYP, "asynInt32")
		field(INP, "@asyn($(PORT) 0) TRTHRESHOLDHIGH")
	}

####### command #############
	record(longout, "$(P):VT_TRIGGER_CHANNEL:OUT") {
		field(PINI, "1")
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) TRCHANNEL")
	}

	record(longout, "$(P):VT_BUFFER_SIZE:OUT") {
		field(PINI, "1")
		field(DTYP, "asynInt32")
		field(OUT, "@asyn($(PORT) 0) BUFFERSIZE")
	}

	record(ao, "$(P):DELAY:OUT") {
		field(DTYP, "asynFloat64")
		field(OUT, "@asyn($(PORT) 0) SETOFFSET")
		field(PREC, "6")
	}

.......
```

Details please refer to 8424.db, 8424_CS.db and 8424_transient_recorder.db in the software package.

Building an Example Application

To build an example to test the 8424 asyn driver, use EPICS makeBaseApp.pl script to create the example as usual. Then modify the following files to include the driver module(s). Alternatively you can just test the driver by using the example included in the module package.

- example <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

```
ASYN=$(SUPPORT)/asyn/asyn4-14
IPAC=$(SUPPORT)/ipac/ipac-2.11
HY8424ASYN=$(TOP)/..
```

  If the IOC is built on IOC9010 blade with RTEMS, also add this line

```
EPICSPCI=$(SUPPORT)/devlib2-2.0
```

  If the system uses Concurrent VME processor under Linux operating system, the Concurrent device driver and API function module needs to be added. This module can be placed in the SUPPORT directory a structure similar to:

  cctvmeen/include
  /lib/linux-x86

  In the “include” sub-directory, it is the include header file: vme_api_en.h
  In the “lib/linux-x86” sub-directory is the library files: libcctvmeen.a and libvmedriver26.a

  To add this module in the RELEASE, add the following line:

  CCTVMEEN=$(SUPPORT)/cctvmeen

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

```
example_DBD += asyn.dbd
example_DBD += drvIpac.dbd
example_DBD += Hy8424Asyn.dbd

example_LIBS += Hy8424Asyn
example_LIBS += Ipac
example_LIBS += asyn
```

  If the IOC is built on IOC9010 blade with RTEMS, also add these lines

```
example_DBD += epicspci.dbd
example_DBD += epicsvme.dbd
```

```
example_LIBS += epicspci
```

NOTE: to include this epicsvme sounds a bit odd since IOC9010 is not a VME but because it defines pdevLibVirtualOS which is needed by devlib.c due to the legacy, it satisfies the build.

If Conccurent processor for Linux is used, add

example_LIBS += cctvmeen

- <TOP>/xxxApp/Db/Makefile

  Copy example.db to the Db directory and add the following lines in the Makefile of the Db directory:

  ```
  DB += example.db
  ```

- <TOP>/ iocBoot/iocBootexample /Makefile

  If the IOC is built for Linux, modify the ARCH variable value to

  ```
  ARCH = linux-x86
  ```

  Also please make sure the envPath file in iocBoot/iocexample directory is properly set up.

- Build the application from <TOP>

- Modify st.cmd in iocBoot/iocexample as per next section and run the start-up script from here.

- To test the IOC, run CSS screen softTest.opi in example/exampleApp/opi/css folder after the IOC is up and running.

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:
The generic init function:

```
int Hy8424AsynInit(char *portName,
        int vmeSlotNum,
        int ipSlotNum,
        int vectorNum,
        int clockRate,
        int extClock,
        int range)
```

where:

portName	= asyn port name
carrierNum	= carrier index number when adding a carrier card by ipacAddHy8002 call
ipSlotNum	= IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F),
vectorNum	= interrupt vector (has to be none zero),
clockRate	= 0 = 1Hz, 1 = 2Hz, 2 = 5Hz, 3 = 10Hz, 4 = 20Hz, 5 = 50Hz, 6 = 100Hz, 7 = 200Hz, 8 = 500Hz, 9 = 1kHz, 10 = 2kHz, 11 = 5kHz, 12 = 10khz, 13 = 20Khz, 14 = 50kHz, 15 = 100kHz, 16 = 200khz, 17 = 500Khz, 18 = 1MHz.
extClock	= 0 = internal, 1 = extrenal,
range	= 0 : +/-10V, 1 : +/-5V

For continuous mode:

```
int Hy8424ContinueMode(char *portName,
          int average,
          int fastADC)
```

where:

portName	= asyn port name, the same name string as the generic init routine
average	= number of readings to SUM for average
fastAdc	= flag to say if the ADC is running at fast speed for normal use. =1 fast, =0 slow for MCA & EPID records

For trigger mode:

```
int Hy8424TriggerMode(char *portName,
          int samples,
          int average,
          double offset,
          int fastADC,
          int triggerEdge)
```

Where: -

portName	= asyn port name
samples	= number of samples post trigger
average	= number of readings to SUM for average
offset	= Offset to start collecting after trigger.
fastAdc	= flag to say if the ADC is running at fast speed for normal use. =1 fast, =0 slow for MCA & EPID records
triggerEdge	= 0 : rising edge; 1 : falling edge; 2 : both edge

For gated mode:

```
int Hy8424GatedMode(char *portName,
          int average,
          double offset,
          int fastADC)
```

Where: -

portName	= asyn port name
average	= number of readings to SUM for average
offset	= Offset from the start (or end if negative) of the gated period to the ADC readings to return
fastAdc	= flag to say if the ADC is running at fast speed for normal use. =1 fast, =0 slow for MCA & EPID records

For simple transient recorder mode:

```
int Hy8424SimpleTRMode(char *portName,
          int samples,
          double delay,
          double thresholdlow0,
          double thresholdhigh0,
          double thresholdlow1,
          double thresholdhigh1,
          double thresholdlow2,
          double thresholdhigh2,
          double thresholdlow3,
          double thresholdhigh3,
          int outputEdge,
          int stopInEdge)
```

Where: -

portName	= asyn port name
sample	= number of samples post trigger
delay	= delay time from the trigger to the start point of acquisition
thresholdlow0	= First threshold point for channel 0. In voltage unit
thresholdhigh0	= Second threshold point for channel 0. In voltage unit
thresholdlow1	= First threshold point for channel 1. In voltage unit
thresholdhigh1	= Second threshold point for channel 1. In voltage unit
thresholdlow2	= First threshold point for channel 2. In voltage unit
thresholdhigh2	= Second threshold point for channel 2. In voltage unit
thresholdlow3	= First threshold point for channel 3. In voltage unit
thresholdhigh3	= Second threshold point for channel 3. In voltage unit
outputEdge	= Start Out TTL level. 0=high, 1=low
stopInEdge	= Stop in TTL level: 0=high, 1=low

For voltage trigger transient recorder mode:

```
int Hy8424VoltageTRMode(char *portName,
        int sample,
        int VTChannel,
        double thresholdlow,
        double thresholdhigh,
        int buffer,
        int outputEdge,
        int stopInEdge)
```

Where: -

portName	= asyn port name
sample	= number of samples post trigger
VTChannel	= voltage trigger channel. 0~3
thresholdlow	= First threshold point for VTChannel . In voltage unit
thresholdhigh	= Second threshold point for VTChannel. In voltage unit
buffer	= Circular buffer size. 0~65535
outputEdge	= Start Out TTL level. 0=high, 1=low
stopInEdge	= Stop in TTL level: 0=high, 1=low

Example1: normal ADC

```
Hy8424AsynInit("ADC8424", 0, 3, 91, 18, 0, 0)
Hy8424VoltageTRMode("ADC8424", 10000, 0, 1, -4, 1000, 0, 0)
```

This configures the 8424 card with
- port name: "ADC8424"
- carrierNum = 0
- IP slot = 3 (slot 'D')
- interrupt vector = 91
- scanning rate = 1MHz
- clock source = internal
- range = +/-10V

The ADC is configured as voltage triggered transient recorder mode with
- samples = 10000
- channel 0 as triggering channel
- lower threshold = 1
- upper threshold = -4
- circular buffer size = 1000
- TTL output for synchronisation on rising edge

External stop on rising edge

Start up Script Example

The following example is for an IOC that uses VxWorks5.5, MVME5500 processor board and runs as simple transient recorder mode.

```
#!$(INSTALL)/bin/vxWorks-ppc604_long/example
cd "/dls_sw/work/R3.14.8.2/support/Hy8424ip-asyn/1-0/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)

############################################################
#                 Carrier Card Configuration
############################################################
# Hytec VME8002/8003/8004 carriers under VxWorks
# IPAC1=ipacAddHy8002("VMEslot,INTlevel,IPMEM=2")
# ARGS                                    8002/8003/8004
#   ID -- VME slot                  2~21
#   INTLevel -- INT level.      0~7
#==========================================================
# Hytec IOC9010/PCIe6335/uTCA7002 carriers under Linux
# ipacAddHyLinux9010("ID,INTlevel")
# ARGS                                    IOC9010       PCIe6335    uTCA
#   ID -- carrier ID           99     carrier ID  carrier ID
#   INTLevel -- INT level.     0~7    0~7         0~7 (not used, don't care)
#==========================================================

IPAC3 = ipacAddHy8002("3,2,IPMEM=2")
```

```
############ This init is needed for all modes #############
#int Hy8424AsynInit(char *portName,  "ADC8424"
#  int carrierNum,      0
#  int ipSlotNum,   0
#  int vectorNum,   88
#  int clockRate,   9 (1kHz) 1~18 = 1Hz ~ 1MHz
#  int extClock,    0=internal, 1=external
#  int range,       0=+/-10V, 1=+/-5V
Hy8424AsynInit("ADC8424", 0, 3, 91, 18, 0, 0)
#
#int Hy8424ContinueMode(char *portName,  "ADC8424"
#  int average,     1000
#  int fastADC,     1=fast ADC, 0=mca & EPID support
#Hy8424ContinueMode("ADC8424", 1000, 1)
#
#int Hy8424TriggerMode(char *portName,  "ADC8424"
#  int samples,     10000
#  int average,     1
#  double offset,   Offset to start collecting after trigger
#  int fastADC,     1=fast ADC, 0=mca & EPID support
#  int triggerEdge) 0
#Hy8424TriggerMode("ADC8424", 1000, 1, 0, 1, 0)
#
#int Hy8424GatedMode(char *portName,  "ADC8424"
#  int average,     1
#  double offset,   offset to start collecting after trigger
#  int fastADC,     1=fast ADC, 0=mca & EPID support
#Hy8424GatedMode("ADC8424", 1, 10, 1)
#
# int Hy8424SimpleTRMode(char *portName, int sample, double delay, double
thresholdlow0,
#           double thresholdhigh0, double thresholdlow1, double thresholdhigh1,

#           double thresholdlow2, double thresholdhigh2, double thresholdlow3,
#           double thresholdhigh3,  int outputEdge, int stopInEdge)
# portName   = asyn port name for this port
# samples,        256k - delay*clockrate
# delay,          in second
# thresholdlow0  =low threshold channel 0
# thresholdhigh0 = upper threshold channel 0.
# thresholdlow1  =low threshold channel 1
# thresholdhigh1 = upper threshold channel 1.
# thresholdlow2  =low threshold channel 2
# thresholdhigh2 = upper threshold channel 2.
# thresholdlow3  =low threshold channel 3
# thresholdhigh3 = upper threshold channel 3.
# outputEdge      =trigger out edge. 0=rising, 1=falling
# stopInEdge      =stop in edge. 0=rising, 1=falling
Hy8424SimpleTRMode("ADC8424", 10000, 0.0, 1, -4, 4, -0, 6, -2, 5, -3, 0, 0)
#
```

```
# int Hy8424VoltageTRMode(char *portName, int sample, int VTChannel, double
thresholdlow,
#           double thresholdhigh, int buffersize, int outputEdge, int stopInEdge)
# portName        = asyn port name for this port
# samples,        256k - buffersize
# VTChannel       =voltage trigger channel. 0~3
# thresholdlow  =low threshold for VTChannel
# thresholdhigh =upper threshold for VTChannel.
# buffersize      =circular buffer size. 0~65535
# outputEdge      =trigger out edge. 0=rising, 1=falling
# stopInEdge      =stop in edge. 0=rising, 1=falling
#Hy8424VoltageTRMode("ADC8424", 10000, 0, 1, -4, 1000, 0, 0)
#
## Load record instances
#dbLoadRecords("db/8424.db","P=CARD2,PORT=ADC8424")
#dbLoadRecords("db/8424_CS.db","P=CARD2,PORT=ADC8424")
dbLoadRecords("db/8424_transient_recorder.db","P=CARD2,PORT=ADC8424")

# set trace output level for asyn port " ADC8424"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                    0x01: error,
#                    0x11: errors, warnings and debug
#                    0x00: silent
asynSetTraceMask( " ADC8424", 0, 0x00 )
# all driver level messages

iocInit()
```

The following example is for VME IOC with Linux with Concurrent processor and runs as continuous mode .

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
< envPaths

cd ${TOP}

epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")
epicsEnvSet(EPICS_CA_AUTO_ADDR_LIST, "NO")
epicsEnvSet(EPICS_CA_ADDR_LIST, "172.23.81.195")

## Register all support components
```

```
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)

# For VME/Linux/Conccurent Processor
ipacAddHy8002Concurrent("3,2,IPMEM=2")

############ This init is needed for all modes #############
#int Hy8424AsynInit(char *portName,  "ADC8424"
#  int carrierNum,          0
#  int ipSlotNum,   0
#  int vectorNum,   88
#  int clockRate,   9 (1kHz) 1~18 = 1Hz ~ 1MHz
#  int extClock,    0=internal, 1=external
#  int range,       0=+/-10V, 1=+/-5V
Hy8424AsynInit("ADC8424", 0, 3, 91, 18, 0, 0)
#
#int Hy8424ContinueMode(char *portName,  "ADC8424"
#  int average,     1000
#  int fastADC,     1=fast ADC, 0=mca & EPID support
Hy8424ContinueMode("ADC8424", 1000, 1)
#
#int Hy8424TriggerMode(char *portName,  "ADC8424"
#  int samples,     10000
#  int average,     1
#  double offset,   Offset to start collecting after trigger
#  int fastADC,     1=fast ADC, 0=mca & EPID support
#  int triggerEdge) 0
#Hy8424TriggerMode("ADC8424", 1000, 1, 0, 1, 0)
#
#int Hy8424GatedMode(char *portName,  "ADC8424"
#  int average,     1
#  double offset,   offset to start collecting after trigger
#  int fastADC,     1=fast ADC, 0=mca & EPID support
#Hy8424GatedMode("ADC8424", 1, 10, 1)
#
# int Hy8424SimpleTRMode(char *portName, int sample, double delay, double thresholdlow0,
#                   double thresholdhigh0, double thresholdlow1, double thresholdhigh1,
#                   double thresholdlow2, double thresholdhigh2, double thresholdlow3,
#                   double thresholdhigh3,  int outputEdge, int stopInEdge)
# portName   = asyn port name for this port
# samples,         256k - delay*clockrate
# delay,           in second
# thresholdlow0  =low threshold channel 0
# thresholdhigh0 = upper threshold channel 0.
# thresholdlow1  =low threshold channel 1
# thresholdhigh1 = upper threshold channel 1.
```

```
# thresholdlow2  =low threshold channel 2
# thresholdhigh2 = upper threshold channel 2.
# thresholdlow3  =low threshold channel 3
# thresholdhigh3 = upper threshold channel 3.
# outputEdge     =trigger out edge. 0=rising, 1=falling
# stopInEdge     =stop in edge. 0=rising, 1=falling
#Hy8424SimpleTRMode("ADC8424", 10000, 0.0, 1, -4, 4, -0, 6, -2, 5, -3, 0, 0)
#
# int Hy8424VoltageTRMode(char *portName, int sample, int VTChannel, double thresholdlow,
#                     double thresholdhigh, int buffersize, int outputEdge, int stopInEdge)
# portName       = asyn port name for this port
# samples,       256k - buffersize
# VTChannel     =voltage trigger channel. 0~3
# thresholdlow  =low threshold for VTChannel
# thresholdhigh =upper threshold for VTChannel.
# buffersize     =circular buffer size. 0~65535
# outputEdge     =trigger out edge. 0=rising, 1=falling
# stopInEdge     =stop in edge. 0=rising, 1=falling
#Hy8424VoltageTRMode("ADC8424", 10000, 0, 1, -4, 1000, 0, 0)
#
## Load record instances
dbLoadRecords("db/8424.db","P=CARD2,PORT=ADC8424")
dbLoadRecords("db/8424_CS.db","P=CARD2,PORT=ADC8424")
#dbLoadRecords("db/8424_transient_recorder.db","P=CARD2,PORT=ADC8424")


# set trace output level for asyn port "ADC8424"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                 0x01: error,
#                 0x11: errors, warnings and debug
#                 0x00: silent
asynSetTraceMask( "ADC8424", 0, 0x00 )
# all driver level messages

iocInit()
```

20. Hy8001 8001 VME 64 Channel digital and Carrier Card Asyn Driver

General Information

8001 VME module can be used as either 64 channel digital input/output card (with the J1 jumper not shorted) or 32 digital channel input/output card plus two IP cards (with J1 jumper shorted). So when used as latter case, it is a carrier module plus its onboard digital IOs. As such, the driver support is split into two parts as if it is a conventional carrier card, i.e. a carrier module or base module by using Ipac + drvHy8001.c and a asyn module Hy8001Asyn for the
digital IOs.

When using 8001 as carrier, i.e. with other IP modules on board, Ipac + drvHy8001.c provides the base management for those IPs. The user can load this plus the IP
drivers such as Hy8414ip-asyn module for 8414 ADC.

1). When used as 64 channel digital IO case, J1 jumper has to be out and Hytec double size digital IO IP module 8501 is plugged in.

The IOs are grouped in A, B, C and D 4 groups with channel 0~15 in group A, channel 16~31 in group B, channel 32~47 in group C and channel 48~63 in group C. The channels can be set to all inputs (dir=0), half inputs (A and B), half outputs (C and D) (dir=1), half outputs (A and B), half inputs (C and D) (dir=2) or all outputs (dir=3). The channels can be accessed by records such as:

```
record(bi, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(ZNAM, "Zero")
        field(ONAM, "One")
}
```

for input or

```
record(bo, "$(P):CHANNEL32:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 32) DATA")
        field(ZNAM, "Off")
        field(ONAM, "On")
```

```
}
```

for output. Inputs can be also monitored by I/O Intr records like:

```
record(bi, "$(P):INTRCHANNEL16:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 16) DATA")
        field(ZNAM, "Zero")
        field(ONAM, "One")
}
```

if the channel is not masked out for generating interrupt. Also, once a channel generates an interrupt, the driver will stop memory writing and fill the I/O Intr records. User can read out the history data from the point that generates the interrupt by using records like:

```
record(waveform, "$(P):INTRWAVEFORMCHANNEL0:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32ArrayIn")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}
```

To allow the scanning to write to the memory again, user needs to issue a command by this record with value of "1".

```
record(longout, "$(P):WRITETOMEMORY:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) USEMEMORY")
}
```

The user can use mbbi/mbbo records for group access as well such as:

```
record(mbbi, "$(P):CHANNEL0TO15:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynUInt32Digital")
        field(INP, "@asynMask($(PORT) 0, 0xFFFF) DATA")
}
```

in this case, the number 0 in "@asynMask($(PORT) 0, 0xFFFF) DATA" is the group number.

For inputs, once the scan starts, it also writes the last known data into memory as per the scanning rate. User can use the waveform record to get the history of a channel:

```
record(waveform, "$(P):WAVEFORMCHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32ArrayIn")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(NELM,"32")
        field(FTVL,"LONG")
}
```

For outputs, memory can store a series of pattern data to form a sequential state changes. The pattern data can be downloaded by records like:

```
record(waveform, "$(P):WAVEFORMPATTERN:OUT") {
        field(DTYP, "asynInt32ArrayOut")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(NELM,"32")
        field(FTVL,"ULONG")
}
```

Example:

```
caput -a CARD1:WAVEFORMPATTERN:OUT 4 1437226410(0x55AA55AA)
2863289685(0xAAAA5555) 1431699455(0x5555FFFF) 1442797055(0x55FF55FF)
```

This downloads 4 32bit data to the memory. The lower half of the first 32bit is channel 0~15, the upper half is channel 16~31. The lower half of the second 32bit
is channel 32~47, and the upper half is channel 48~63. And it repeats.

2). When used as onboard 32 channel digital IOs and IP carrier card case, J1 jumper has to be shorted and the two IP slots can be used for any Hytec IP modules.

In this case, apart from the number of channels becomes 32 rather than 64, all other functionalities are the same as 1). So the channel index starts from 0 to 31. The group
starts from 0 to 1.

There is a protection in the code to prevent writing numbers to the input channels. It will print out a message on the terminal window and does not write anything to the hardware. But user can read the cached output values from the output channels.

Support Modules

1). asyn driver version asyn4-12 or later.
2). ipac module version ipac-2.11 plus drvHy8001.c.
3). EPICS core R3.14.8.2 or later.
4). RTEMS R4.9.4 or later.

Configuration 8001 as Carrier Card

This is similar to configure the 8002 series carrier cards.

1). Configuration Command and Parameter

- int ipacAddHYy8001(const char *cardParams);

The parameter string should comprise two (2) to four (4) parameters which are comma separated. The first two are mandate and have to be separated only by one comma. The others are key/value pairs and are optional. The format is defined as

s,i,ROAK=d,MEMOFFS=d

where d is a decimal integer number.

s	defines the VME slot number of the carrier card. Valid number is 2 ~ 21 if 1MB memory space is specified or 2~15 if 2MB memory space is specified
i	defines the interrupt level. Valid number is 0 ~ 7.
ROAK=d	if d =1, it defines carrier card to release the interrupt upon the acknowledgment. If d=0, the interrupt is released by user interrupt service routine. Default is 0.
MEMOFFS=d	this parameter defines the VME end A32 memory access base address. "d" is a decimal number that represents the offset (the upper WORD) of the VME end A32 base address. It is needed when any of the two statements below is true: A. The operating system either VxWorks or RTEMS has defined a non-zero VME_A32_MSTR_BUS macro in the system config.h file. B. The VME crate is not geographical addressing facilitated. In such a system, user must use this to set up base address for A32. For a VME crate that is geographical addressing facilitated, and the system

defines a non-zero VME_A32_MSTR_BUS macro, then it is needed. But if VME_A32_MSTR_BUS macro is defined as 0, then this is optional. Setting this the driver will turn off the carrier card geographical addressing by setting a bit in the CSR.

Note: MEMOFFS has nothing to do with A16 base address formation. A16 base address is determined either by geographical addressing or by carrier board on board jumper settings. For VME crate that is not geographical addressing facilitated, both 8001 and 8004 carriers need to use on board jumpers (J6~J10) to set up (On 8004 carrier, moving the jumpers to "manual" positions). When the VME crate is geographical addressing facilitated, for 8001 carrier, A16 base address is determined by the crate geographical addressing facility, i.e. determined automatically by the slot number where the carrier is plugged in (the actually A16 base address is determined as vmeslotnumber << 11). But for 8004 carrier, user can have a choice to either use the on board jumpers to manually set up (moving jumpers J6~J10 away from "auto" to "manual" positions) or let the geographical addressing to determine it (keep all J6 ~ J10 to "auto" position).

Calculation of MEMOFFS:

As mentioned above, MEMOFFS setting represents the upper WORD of A32 VME address. Few things need to be considered when doing the calculation: IPMEM setting and the VME_A32_MSTR_BUS and VME_A32_MSTR_SIZE macros definition in the config.h file of the BSP.

IPMEM defines the memory size per IP card. Either 8001 or 8004 has up to 4 IPs so the carrier memory size is 4 times of the IP memory. The minimum size of an IP which is also the default setting (if IPMEM is not defined) is 1MB. Hence the MEMOFFS should start from address line A22 as shown below

```
MEMOFFS BIT 15  14  13  12  11  10  09  08  07  06  05  04  03  02  01  00
        A31 A30 A29 A28 A27 A26 A25 A24 A23 A22   0   0   0   0   0   0
```

The MEMOFFS must be defined such that any two carriers in the same crate shouldn't have overlapped memory area. So when IPMEM changes, the starting address line for calculating MEMOFFS changes as well as illustrated below:

IPMEM	memory per IP	carrier memory size	starting address line
1	1MB	4MB	A22
2	2MB	8MB	A23
4	4MB	16MB	A24

8 8MB 32MB A25

all address lines below this bit must be 0.

The MEMOFFS calculation also needs to take VME_A32_MSTR_BUS and VME_A32_MSTR_SIZE macros into account. These macros are defined in the BSP config.h file. VME_A32_MSTR_BUS is the start address of VME end defined by the BSP and VME_A32_MSTR_SIZE is the valid size of VME memory.

As such, the definition of MEMOFFS must be in the range between VME_A32_MSTR_BUS ~ VME_A32_MSTR_BUS + VME_A32_MSTR_SIZE. Otherwise the BSP range check will reject the A32 base address register. The user will see an error during the IOC boot time saying that the ipacAddHy8001 returned an error.

In principle, calculating MEMOFFS doesn't have to correspond it to VME slot number that the carrier is plugged in. The only thing matters is as said that any two MEMOFFS settings for any two carriers in the same crate should not overlap. Yet associating the VME slot number in the calculation just makes better logical sense and fits the natural of human being's thinking. Some examples are shown below.

Let's assume IPMEM=1 (the default setting), this gives 4MB memory space for a 8001 carrier so starting address line is A22. The remaining must be 0.

MEMOFFS BIT 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00
A31 A30 A29 A28 A27 A26 A25 A24 A23 A22 0 0 0 0 0 0

For a carrier in VME slot 2, we can define its A32 base address as 0x00400000, plus VME_A32_MSTR_BUS. For VME slot 3, it could be 0x00800000 plus VME_A32_MSTR_BUS and for VME slot 4, it could be 0x00C00000 plus VME_A32_MSTR_BUS and so forth.

Assuming VME_A32_MSTR_BUS is 0x20000000, then for VME slot 4, the calculated base address should be 0x00C00000 + 0x20000000 = 0x20C000000. Hence the MEMOFFS = 8384 (decimal, i.e. 0x20C0). For slot 5, the derived base address could be 0x01000000 + 0x20000000 = 0x21000000. Hence the MEMOFFS = 8448 (decimal, i.e. 0x2100) and so forth.

Now if IPMEM=2, this gives 8MB memory space for each 8001 carrier so the starting address line is A23. The remaining must be 0.

MEMOFFS BIT 15 14 13 12 11 10 09 08 07 06 05 04 03 02 01 00
A31 A30 A29 A28 A27 A26 A25 A24 A23 0 0 0 0 0 0 0

For a carrier in VME slot 2, we could define its A32 base address as 0x00800000 plus VME_A32_MSTR_BUS. For VME slot 3, the base address could be 0x01000000 plus VME_A32_MSTR_BUS and for VME slot 4, the base address could be 0x01800000 plus VME_A32_MSTR_BUS and so forth.

Assuming VME_A32_MSTR_BUS is still 0x20000000, then for VME slot 4, the calculated base address should be 0x01800000 + 0x20000000 = 0x218000000. Hence the MEMOFFS = 8576 (decimal, i.e. 0x2180). For slot 5, the derived base address could be 0x02000000 + 0x20000000 = 0x22000000. Hence the MEMOFFS = 8704 (decimal, i.e. 0x2200) and so forth.

- int Hy8001CarrierInfo(int carrier);

where 'carrier' is the registered carrier number in the system. If it is specified, this function prints out the specified carrier hardware information. If carrier = 0xFFFF, then all carriers' hardware information will be printed out.

2). Configuration Examples

ipacAddHy8001("3,2)

This indicates that the carrier is in slot 3 and the interrupt level is set to 2. RORA as default. use geographical addressing etc.

ipacAddHy8001("5,4,ROAK=1,MEMOFFS=192 ")

Here the slot is 5, interrupt level is 4. Use ROAK but not using geographic addressing. The memory offset is 192 which means its base address is 0x00C00000 assuming the VME_A32_MSTR_BUS is set to 0x00000000.

3). Interrupt Commands Supported

The interrupt level can be set by the second parameter of the ipacAddHy8001 routine. Individual IP module can be set to generate interrupt or not. The commands supported for ipmIrqCmd are illustrated below.

cmd	Value Returned
ipac_irqGetLevel	Carrier interrupt level (0 ~ 7)
ipac_irqEnable	0 = OK
ipac_irqDisable	0 = OK
ipac_irqPoll	>0 if the interrupt line is active, else 0

(other commands) S_IPAC_notImplemented

Configuration Shell Command for Start-up Script

The configuration ioc shell commands have two functions:

```
int Hy8001AsynInit(char *portName,
                   int vmeSlotNum,
                   int vectorNum,
                   int dir,
                   int usememory)
```

Where:

(1) portName	asyn port name
(2) carrierNum	carrier index number when adding a carrier card by ipacAddHy8001 call
(3) vectorNum	Interrupt Vector (0 - 7)
(4) dir	0: all inputs, 1: AB inputs/CD outputs, 2: AB outputs/CD inputs, 3: all outputs
(5) usememory	0: do not use memory for caching or update, 1: use memory for caching (input) or update (output)

```
int Hy8001AsynExtInit(char *portName,
                      int clocksource,
                      int scanrate,
                      int debrate,
                      int inhibitsource,
                      int continuous,
                      unsigned int intmasklow,
                      unsigned int intmaskhigh,
                      unsigned int debmasklow,
                      unsigned int debmaskhigh)
```

Where:

(1) portName	asyn port name
(2) clocksource	0: internal, 1: external from front panel, 2: external from strobe IN1
(3) scanrate	0: 1kHz/divided by 1000, 1: 10kHz/devided by 100 2: 100kHz/divided by 10, 3: 1MHz/divided by 1
(4) debrate	0: 100Hz/divided by 10000, 1: 200Hz/devided by 5000 2: 500Hz/divided by 2000, 3: 1kHz/divided by 1000
(5) inhibitsource	0: front panel, 1: strobe IN2, 2: strobe IN3, 3: strobe IN4
(6) continuous	1: continuous updating, 0: single shot. For all output mode only

(7) intmasklow interrupt mask for channel 0 ~ 31. Writing "1" to disable interrupt
(8) intmaskhigh interrupt mask for channel 32 ~ 63. Writing "1" to disable interrupt
(9) debmasklow debounce mask for channel 0 ~ 31. Writing "1" to enable debounce
(10) debmaskhigh debounce mask for channel 32 ~ 63. Writing "1" to enable debounce

Example:

```
Hy8001AsynInit("DIO8001", 0, 88, 0, 1)
Hy8001AsynExtInit("DIO8001", 0, 3, 0, 0, 0, 0, 0, 0xFFFFFFFF, 0xFFFFFFFF)
```

This configures the 8001 card with
port name: "DIO8001"
carrierNum = 0
interrupt vector = 0x88
dir = 0, all 64 inputs

clocksource = internal
scanrate = 3, 1MHz
debrate = 0, 100Hz
inhibitsource = 0, front panel
continuous = 0, single shot memory output
intmasklow = allow channel 0~31 interrupt
intmaskhigh = allow channel 32~63 interrupt
debmasklow = allow channel 0~31 debounce
debmasklow = allow channel 32~64 debounce

Database definition file

Database definition file are:

drvIpac.dbd for 8001 carrier/base module
Hy8001Asyn.dbd for the asyn driver

Testing Database(s)

asyn function code:

```
"DATA"              -- [in] query data in all cases
"DIRECTION"         -- [in] set input/output direction
"USEMEMORY"         -- [in] set whether use memory update or not
"CLOCK_SOURCE"      -- [out] set clock source
"SCAN_RATE"         -- [out] set scanning rate for inputs
"DEBRATE"           -- [out] set debounce rate for inputs
"INHIBIT_SOURCE"    -- [out] set inhibit source
"CONTINUOUS"        -- [out] set continuous update for outputs
"INTMASKLOW"        -- [out] set A, B sites interrupt mask
"INTMASKHIGH"       -- [out] set C, D sites interrupt mask
"DEBMASKLOW"        -- [out] set A, B sites debounce mask
"DEBMASKHIGH"       -- [out] set C, D sites debounce mask

"MEMPOINTER"        -- [in] query current memory write pointer
"FWVERSION"             -- [in] query IP card firmware version
"DRIVERVERSION"     -- [in] query driver software version
"SUPPORT"           -- [in] query driver support info
```

These function code can be used in database records for command or settings etc.

Example database records:

```
dbLoadRecords("db/example.db")
```

Query data:

```
record(bi, "$(P):CHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(ZNAM, "Zero")
        field(ONAM, "One")
}

record(bi, "$(P):INTRCHANNEL16:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 16) DATA")
        field(ZNAM, "Zero")
        field(ONAM, "One")
```

```
}

record(bo, "$(P):CHANNEL32:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 32) DATA")
        field(ZNAM, "Off")
        field(ONAM, "On")
}


record(waveform, "$(P):WAVEFORMCHANNEL0:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32ArrayIn")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(NELM,"32")
        field(FTVL,"LONG")
}

record(waveform, "$(P):INTRWAVEFORMCHANNEL0:IN") {
        field(SCAN, "I/O Intr")
        field(DTYP, "asynInt32ArrayIn")
        field(INP, "@asyn($(PORT) 0) DATA")
        field(NELM,"1000")
        field(FTVL,"LONG")
}

record(mbbi, "$(P):CHANNEL0TO15:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynUInt32Digital")
        field(INP, "@asynMask($(PORT) 0, 0xFFFF) DATA")
}

record(mbbo, "$(P):CHANNEL0TO15:OUT") {
        field(DTYP, "asynUInt32Digital")
        field(OUT, "@asynMask($(PORT) 0, 0xFFFF) DATA")
}
```

Settings:

```
record(longout, "$(P):SCANRATE:OUT") {
        field(DTYP, "asynInt32")
        field(OUT, "@asyn($(PORT) 0) SCAN_RATE")
```

```
}
```

Status:

```
record(ai, "$(P):MEMORYPOINTER:IN") {
        field(SCAN, "1 second")
        field(DTYP, "asynInt32")
        field(INP, "@asyn($(PORT) 0) MEMPOINTER")
}

record(ai,"$(P):FIRMWARE_VERSION:IN") {
   field(DTYP,"asynInt32")
   field(INP,"@asyn($(PORT) 0) FWVERSION")
   field(SCAN, "1 second")
}
```

.....

Details please refer to example.db in the software package.

Building an Example Application

To build an example to test the 8001 asyn driver, first build the Ipac module by downloading ipac-2.11 from EPICS website and 8001 carrier/base module from http://www.hytec-electronics.co.uk/Software/Hytec-carrier-drivers-24-08-2012.tar.gz.

- Copy drvHy8001.c into ipac-2.11/drvIpac folder

- Modify ipac-2.11/dbd/drvIpac.dbd to add this line

```
registrar(Hy8001Registrar)
```

- Modify ipac-2.11/drvIpac/Makefile to add this line

```
LIBSRCS += drvHy8001.c
```

- Do commands at <TOP>

```
make clean uninstall
```

make

Then, use EPICS makeBaseApp.pl script to create the example as usual and modify the following files to include the driver module(s).

- <TOP>/configure/RELEASE

  Change the EPICS_BASE and SUPPORT to the proper directories.
  Add ASYN, IPAC modules:

  ASYN=$(SUPPORT)/asyn/asyn4-14
  IPAC=$(SUPPORT)/ipac/ipac-2.11
  HY8001ASYN=$(TOP)/..

- <TOP>xxxApp/src/Makefile

  In the Makefile of the example src, add following lines:

  example_DBD += asyn.dbd
  example_DBD += drvIpac.dbd
  example_DBD += Hy8001Asyn.dbd

  example_LIBS += Hy8001
  example_LIBS += Ipac
  example_LIBS += asyn

- <TOP>/xxxApp/Db/Makefile

  Copy example.db to the Db directory and add the following line in the Makefile of the Db directory:

  DB += example.db

- Build the application from <TOP>

- Modify stexample.src in iocBoot/iocexample as per next section and run the start up script from here.

Start up Script Example

```
#!../../bin/linux-x86/example
#cd "$(INSTALL)"
#< envPaths
#cd ${TOP}

cd "/dls_sw/work/R3.14.8.2/support/Hy8001-asyn/1-0/example"

#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(LINUX_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")

# Load binaries on architectures that need to do so.
# VXWORKS_ONLY, LINUX_ONLY and RTEMS_ONLY are macros that resolve
# to a comment symbol on architectures that are not the current
# build architecture, so they can be used liberally to do architecture
# specific things. Alternatively, you can include an architecture
# specific file.
ld < bin/vxWorks-ppc604_long/example.munch

#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_REPEATER_PORT,"6065")
#$(VXWORKS_ONLY)epicsEnvSet(EPICS_CA_SERVER_PORT,"6064")
epicsEnvSet(EPICS_CA_MAX_ARRAY_BYTES,"3000000")

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)


# Run the configuration function once for each card in the IOC
# This is the function registered in registrarHy8314ip.c
#  Arguments should be something like:
#  * asyn port (string)
#  * VME slot number
#  * IP slot number
#  * - any other arguments that need to be used for configuration
#      at startup time.


# For VME/VxWorks
IPAC3 = ipacAddHy8001("3,2")
```

```
#int Hy8001AsynInit(char *portName,  "DIO8001"
#  int carrierNum,       0
#  int vectorNum,   88
#  int dir          0: all in, 1: AB in/CD out, 2: AB out/CD in, 3: all out
#  int usememory)   0: do not use memory for caching or update, 1: use memory for caching (input)
or update (output)
Hy8001AsynInit("DIO8001", 0, 88, 0, 1)

#int Hy8001AsynExtInit(char *portName,  "DIO8001"
#  int clocksource, 0: internal, 1: external from front panel, 2: external from strobe IN1
#  int scanrate,    0: 1kHz/divided by 1000, 1: 10kHz/devided by 100
#                                              2: 100kHz/divided by 10, 3: 1MHz/divided by 1
#  int debrate,     0: 100Hz/divided by 10000, 1: 200Hz/devided by 5000
#                                          2: 500Hz/divided by 2000, 3: 1kHz/divided by 1000
#  int inhibitsource,   0: front panel, 1: strobe IN2, 2: strobe IN3, 3: strobe IN4
#  int continuous,  1: continuous updating, 0: single shot. For all output mode only
#  int intmasklow,  interrupt mask for channel 0 ~ 31. Writing "1" to disable interrupt
#  int intmaskhigh, interrupt mask for channel 32 ~ 63. Writing "1" to disable interrupt
#  int debmasklow,  debounce mask for channel 0 ~ 31. Writing "1" to enable debounce
#  int debmaskhigh) debounce mask for channel 32 ~ 63. Writing "1" to enable debounce
Hy8001AsynExtInit("DIO8001", 0, 3, 0, 0, 0, 0, 0, 0xFFFFFFFF, 0xFFFFFFFF)

## Load record instances
dbLoadRecords("db/example.db","P=CARD1,PORT=DIO8001")

# set trace output level for asyn port "DIO8001"
# Level: 0x01 = Errors only
# asynSetTraceMask arguments:
#  * asyn port
#  * address of that asynport (i.e. channel number)
#  * verbosity level:
#                  0x01: error,
#                  0x11: errors, warnings and debug
#                  0x00: silent
asynSetTraceMask( "DIO8001", 0, 0x00 )
# all driver level messages

iocInit()
dbl
```

21. IP Module Online Firmware Upgrade

Introduction

The new Xilinx FPGA chip firmware upgrade requires the JTAG programmer or similar devices. This sometimes is not always available on site hence we developed this module and online upgrade mechanism to make life much easier.

The upgrade software is written as a standard EPICS driver based on ipac and asyn modules. In the package, the example builds the IOC which can be loaded exactly the same way as the normal IOC software down to the module.

All actions are done in the module's init routine, which is called during the start up. So please make sure the parameters of this init routine are set properly before loading the IOC.

The new firmware has to be copied in the TOP folder of the example.

int HyFWUpgradeAsynInit(char *portName, int vmeSlotNum, int ipSlotNum, char *fileName, int mode)

where:
portName = asyn port name
vmeSlotNum = carrier index number when adding a carrier card by ipacAddHy8002 call or similar
ipSlotNum = IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F),
fileName = the filename of the firmware to be upgraded. The XXXXvNNN.bit file.
mode = 0: memory test
1: view module ID PROM
2: Verify firmware with .bit file
3: Firmware upgrade

This firmware upgrade asyn software provides 4 modes:

- Memory test
- View module ID PROM
- Verify firmware with specified .bit file
- Firmware upgrade

When changing mode, just modify the script and reload the IOC to execute.

Note: this software package works only in EPICS environment with Hytec online firmware upgradeable modules. Please check with Hytec support if you are sure about the module's upgrade capability.

Memory Test -- mode 0

This does memory read/write test. In this mode, parameter "fileName" is ignored.

If there are errors during the test, it prints out the error times at the end.

View Module ID PROM -- mode 1

This mode does nothing but just display the ID PROM. It can be used for visually verification of the upgrade result. Again, parameter "fileName" is ignored.

Verify Firmware -- mode 2

This reads the current firmware and compares against the specified .bit file to verify whether they match.

The "fileName" parameter is in the form of XXXXvNNN.bit. Where XXXX is the module number such as 8414, 8415, 8424 or 8417 etc. This number MUST match the module number in the IP card's ID PROM. If it doesn't, the verification quits. NNN is the version number like 106 or 206 etc.

During the test, if a block of 132 words matches the firmware, it prints a ".". If a block doesn't match, it prints a "#" symbol.

At the end, it prints out the number of mismatched words.

Firmware Upgrade -- mode 3

This upgrades the fimrware with the specified .bit file in the "fileMame" parameter. The file name needs the correct format as described in the Verify Firmware mode. After the upgrade, it also does verification.

During the verification test, if a block of 132 words matches the firmware, it prints a ".". If a block doesn't match, it prints a "#" symbol.

At the end, it prints out the number of mismatched words.

After the upgrade, modify the st.cmd file to mode 1 then power cycle the IOC. Load the IOC again to verify if the upgrade is successful or not.

Upgrade Procedures

1). Untar the tar file to a direcotry
2). Modify the RELEASE files for both driver module and the example
3). Build the module and example
4). Copy the new firmware .bit file (e.g. 8414v206.bit) to example folder.
5). Modify the st.cmd file in the example/iocBoot/iocexample folder
6). Run the IOC

Support Modules

1). asyn driver version asyn4-12 or later.

2). ipac module version ipac-2.11 plus one of the Hytec carrier card drivers such as
drvHy8002.c for VxWorks or RTEMS under VME64x with 8002/8003/8004 carriers;
drvHyLinuxCarrier.c for Linux with IOC9010/PCIe6335/uTCA7002 carriers;
drvHyRTEMSCarrier.c for RTEMS with IOC9010 blade;
drvHy8002Concurrent.c for VME with Conccurrent processor for Linux.

3). devLib2 version 2.1 or later if using RTEMS on IOC9010 blade.

4). EPICS core R3.14.8.2 or later.

5). RTEMS R4.9.4 or later if using RTEMS os.

6). If Concurrent processor for Linux is used, cctvmeen module and hytec_cct_driver device driver are needed. Please contact Hytec for more information.

Configuration of the Carrier Card

Please refer to chapter 3 for detail installation.

Database definition file

Database definition file is: Firmware.dbd.

Testing Database(s)

Loading the database is optional.

asyn function code:

```
"ERROR"                    -- [in] query errors
"DRIVERVERSION"            -- [in] query driver software version
```

Example database records:

```
dbLoadRecords("db/FWupgrade.db,"P=IP,PORT=FWUPGRADE"")
```

Query data:

```
record(ai,"$(P):ERROR:IN") {
   field(DTYP,"asynInt32")
   field(INP,"@asyn($(PORT) 0) ERROR")
   field(SCAN, "1 second")
}

record(ai,"$(P):DRIVER_VERSION:IN") {
   field(DTYP,"asynInt32")
   field(INP,"@asyn($(PORT) 0) DRIVERVERSION")
   field(SCAN, "1 second")
}
```

Building the Software

To build the software (module and example), please follow the steps below.

- unzip the tar file to a folder. This creates FirmwareUpgrade folder with a version number underneath (1-1 for e.g., the driver TOP)

- modify <TOP>/configure/RELEASE file with the correct EPICS_BASE and SUPPORT settings.

If Conccurent processor for Linux is used, run device driver at system boot. And also copy the cctvmeen module into the prod folder and add
CCTVMEEN=$(SUPPORT)/cctvmeen

- build the driver module

- modify example/configure/RELEASE file with the correct EPICS_BASE and SUPPORT settings.

If Conccurent processor for Linux is used, run device driver at system boot. Copy the cctvmeen module into the prod folder and add

CCTVMEEN=$(SUPPORT)/cctvmeen

Also add the following line to the example/exampleApp/src/Makefile

example_LIBS += cctvmeen

- build the example IOC

- modify st.cmd in example/iocBoot/iocexample folder to proper slot numbers and mode etc.

- load the IOC

Configuration Shell Command for Start-up Script

int HyFWUpgradeAsynInit(char *portName, int vmeSlotNum, int ipSlotNum, char *fileName, int mode)

Where:
portName = asyn port name
vmeSlotNum = carrier index number when adding a carrier card by ipacAddHy8002 call or similar
ipSlotNum = IP slot number on the carrier board (0 = A, 1 = B, 2 = C, 3 = D, 4 = E, 5 = F),
fileName = the filename of the firmware to be upgraded. The XXXXvNNN.bit file.
mode = 0: memory test
1: view module ID PROM
2: Verify firmware with .bit file

3: Firmware upgrade

Please make sure the new firmware is copied in the TOP folder of the example.

Example1: to upgrade 8424 IP card firmware to version 105 with 8004 carrier in VME slot 3 and IP card is slot B. The start up script should have the following lines.

```
ipacAddHy8002("3,2,IPMEM=2")
IPAC3 = ipacLatestCarrier()
HyFWUpgradeAsynInit("FWUPGRADE", IPAC3, 1, "8424v105.bit", 3)
```

Example2: to verify 8414 IP card with firmware file of 8414v105.bit in Linux IOC9010 slot A. The start up script should have the following lines.

```
ipacAddHyLinux9010("99,1")
HyFWUpgradeAsynInit("FWUPGRADE", 0, 0, "8424v105.bit", 2)
```

Start-up Script Example

The following example is for an IOC that uses VxWorks5.5, MVME5500 processor board.

```
#!../../bin/linux-x86/example
cd "/dls_sw/work/R3.14.12.2/support/FirmwareUpgrade/1-1/example"

ld < bin/vxWorks-ppc604_long/example.munch

## Register all support components
dbLoadDatabase("dbd/example.dbd")
example_registerRecordDeviceDriver(pdbbase)

# For PCI/Linux IOC, use
#ipacAddHyLinux9010("99,1")

# For PCI/RTEMS IOC, use
#ipacAddHyRTEMS9010("1,4,0")

# For VME/VxWorks
ipacAddHy8002("3,2,IPMEM=2")
IPAC3 = ipacLatestCarrier()
```

```
# For VME/Linux/Conccurent Processor
#ipacAddHy8002Concurrent("4,2,IPMEM=2")

############ Command for Firmware upgrade #############
#int HyFWUpgradeAsynInit(char *portName,
#  int vmeSlotNum,              #carrier serial number
#  int ipSlotNum,          #IP slot number
#  char* fileName,              #binary file name
#  int mode)                    #mode=0:memory test
#                                    #1:show IP module,
#                                          #2:veryfy firmware,
#                                          #3:upgrade firmware
HyFWUpgradeAsynInit("FWUPGRADE", IPAC3, 1, "8424v105.bit", 2)

dbLoadRecords("db/FWupgrade.db","P=IP,PORT=FWUPGRADE")

iocInit()
```

22. Acknowledgement

As all other EPICS drivers in the community, Hytec device drivers are a collaboration of many developers' contribution over the years. This includes Steve Hunt (Paul Scherrer Institut, Switzerland, steven.hunt@sls.ch), Pete Owen (Diamond Light Source), Walter Scott/David Brownless/Darrell Nineham, Mark Woodward/Graham Cross (Hytec Electronics Ltd), me and software engineers from PSI, Diamond Light Source, SLAC and other laboratories around the world.

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Jim Chen
25/May/2011

23. Bibliography

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